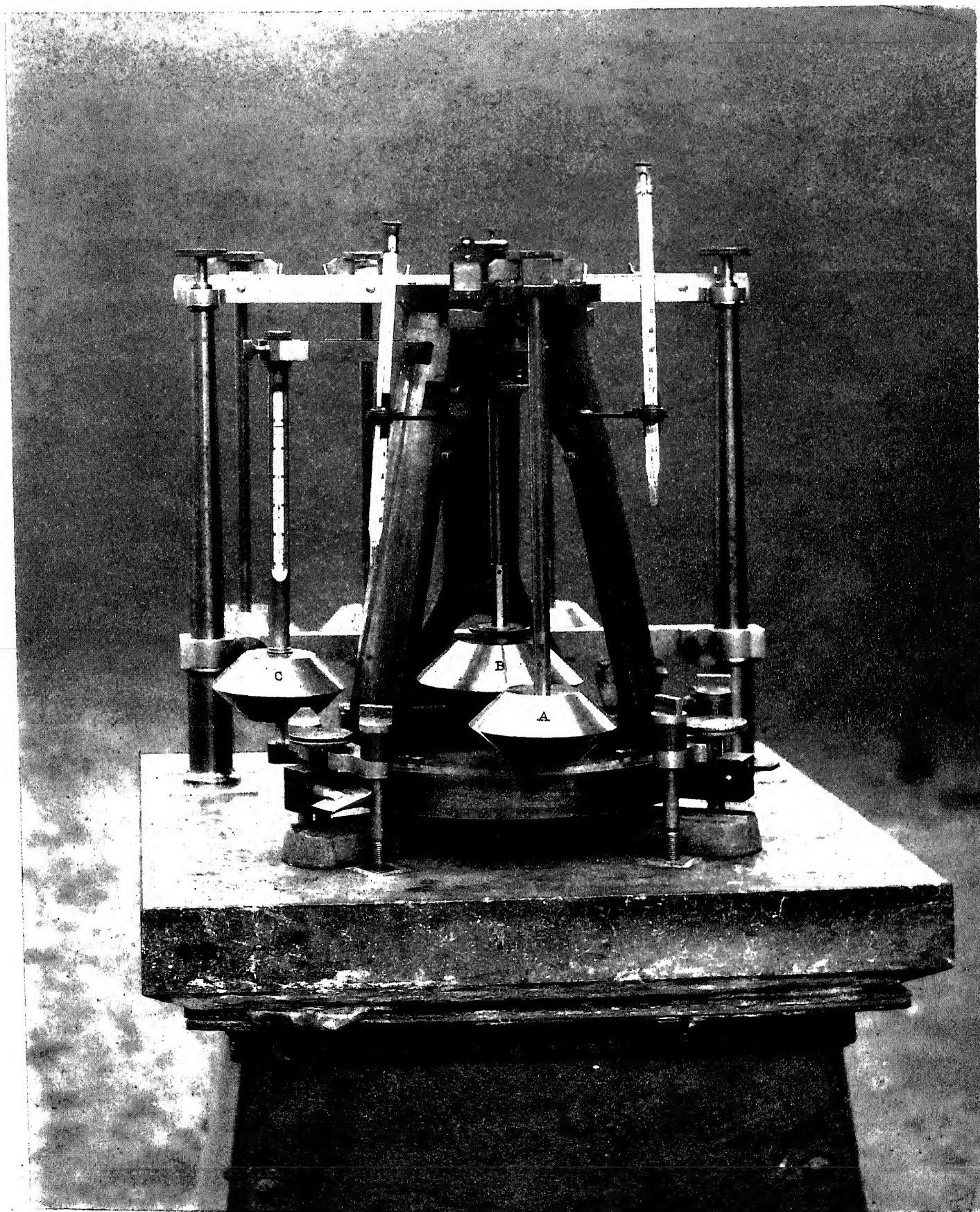


THE PENDULUM APPARATUS.



Photogravure.

Survey of India Offices, Calcutta, March, 1908.

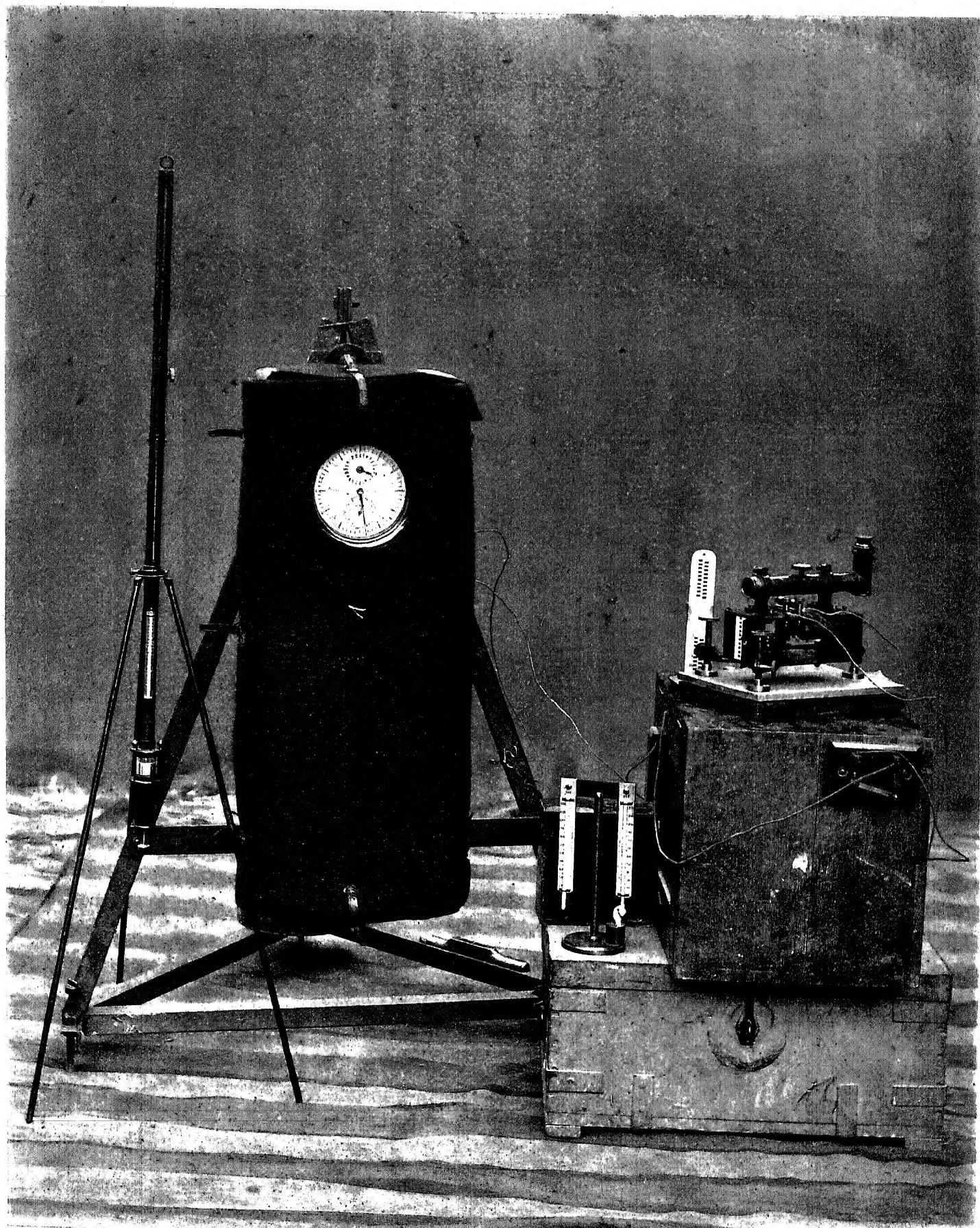
STAND WITH PENDULUMS IN POSITION FOR THE FLEXURE OBSERVATION.

A. Invariable Pendulum.

B. Auxiliary Pendulum.

C. Dummy Pendulum containing Thermometer.

THE PENDULUM APPARATUS.



Photogravure.

Survey of India Offices, Calcutta, March, 1908.

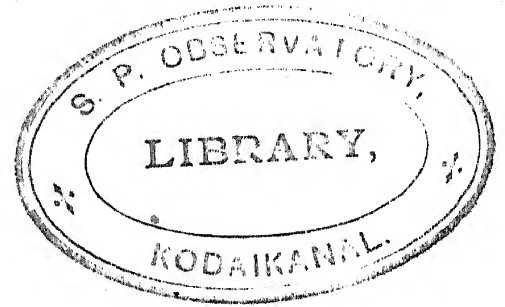
CLOCK, FLASH-BOX AND ACCESSORIES.

Survey of India.

PROFESSIONAL PAPER—No. 10.

THE
PENDULUM OPERATIONS
IN INDIA

1903 to 1907



BY

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WITH AN APPENDIX BY

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PREFACE.

This paper contains a detailed account of all the observations made with the Indian half-seconds pendulum apparatus from the date of its purchase in 1903 to the end of the season 1906-07.

A gravimetric survey of the whole country is the ultimate object of the operations, of which the first few are here described, and nothing less will serve to elucidate all the problems that it is sought to solve; but this is a far off ideal and as it is well to have some more immediate goal in view, to fix ideas and to give definiteness to the programme of work of each year, two primary problems were attacked in the first instance.

These were, to ascertain the extent to which visible excesses of mass, such as mountains, are compensated by deficient density; and to test with the pendulums the truth of the inferences drawn by Colonel Burrard from the Astronomical Latitudes and Longitudes, that is to say, to find out whether there exists a chain of excessive density running more or less parallel to the Himalayas, distant some 150 miles from them and extending from the Bay of Bengal to the Punjab.

Captain Basevi's celebrated observation in 1871, with the Royal Society's Pendulums, at Moré at an elevation of 15400 feet above the sea, gave a result which seemed to show that the mountain mass was entirely compensated by deficient density: that is to say, his value of gravity was the same as would have been expected if the observation had been made in a balloon floating at a height of 15400 feet above a plain at sea level. There are reasons however for doubting whether this observation was trustworthy. It was made under circumstances of great difficulty and Captain Basevi was in very bad health.

The story of how this indomitable observer lost his life while pushing on from Moré to a still higher altitude need not be retold here, but it is proper to remark that, though every care was taken by his successors in reducing the Moré observations, it is possible that had he lived he might have had suggestions to make which would have altered the value deduced from his work.

Colonel Burrard has shewn, in Professional Paper No. 5, that total compensation is incompatible with the deflections of the plumb-line revealed by the latitude observations at and near the foot of the hills. Archdeacon Pratt's theory of mountain compensation was in a large measure based on the smallness of the deflections observed at Kaliána, but Colonel Burrard has shewn that this is explained by the presence of a line of excessive density, in the position mentioned above, and that many other apparent anomalies, which were unknown to the archdeacon, may also be accounted for in the same way.

No station of altitude equal to that of Moré has been visited with the new apparatus, but five stations in the Himalayas and two in the Baluchistan hills are included in the present series, the highest being Sandakphu, 11766 feet.

At all these points a deficiency of density is revealed, but in no case does it amount to total compensation and at Sandakphu it is equivalent to not much more than one-third of the apparent mass. Under all the submontane and mountain stations there appears to be a deficiency which is nearly constant in amount and is not proportional to the height of the station; this applies not only to the Himalayan stations but to those on and at the foot of the Baluchistan ranges also.

Colonel Burrard's hidden chain has been crossed in two places and in each it has made its presence unmistakeably felt.

In the plains of Bengal its crest lies near the station of Kisnapur, (latitude $25^{\circ} 2'$, longitude $88^{\circ} 28'$) and in the Punjab somewhere between Ferozepore and Montgomery (about latitude $30^{\circ} 50'$, longitude $74^{\circ} 30'$).

Noteworthy features are the trough of great deficiency which lies at the foot of the mountains of Northern India, and the way in which this deficiency gradually diminishes and finally gives place to an excess of density at a distance of 100 to 150 miles from them. This is seen on five different lines, namely:—

- (i.) On the line extending southwards from Rájpur to Gesupur:
- (ii.) On the line from Siliguri to Kisnapur and Chatra:
- (iii.) On the line from Pathámkot to Ferozepore.

These three lines start from the base of the Himalayas.

(iv.) On the line from Dera Gházi Khan near the base of the Suleman Mountains through Multán to Montgomery, and lastly (v.) there is the station of Sibi at the foot of the Baluchistan hills with Jacobabad 120 miles further from them.

These several ranges of hills are all of similar structure. It will be of great interest to ascertain whether the same features present themselves in the case of the mountains of Southern and Central India which are of a different character. Observations which will throw light on this are in progress.

As far as the work has now advanced it will be seen that the theory of total compensation of mountain masses is not supported and that the truth of Colonel Burrard's deductions from the observed deflections of the plumb-line is confirmed.

But observations at stations further in among the hills are required before we can make any general statement as to the amount of compensation that affects the Himalayan masses as a whole, and numerous stations along and on both sides of the hidden chain must be visited to enable us to form a correct idea of its position and shape. With regard to the Himalayas I do not think that stations at great altitudes will be the best; the difficulties of carrying out observations of adequate accuracy in very exposed positions are enormous, and the important point is, in my opinion, to get away from the fringe of the hills rather than to get up as high as possible.

In carrying out these observations and in preparing this account of them I have received help from many quarters and I take this opportunity of tendering my most grateful acknowledgments.

First and foremost I have to thank Colonel Burrard, to whom the inception of the undertaking is wholly due, for constant encouragement, advice and support which have smoothed many difficulties from my path.

Mr. Eccles has helped me much in preparing the account for the press and has given me the benefit of his knowledge in many ways. Captain H. M. Cowie has frequently assisted me in the observatory and has read many of the proofs.

My Assistant Babu Hanuman Prasad, who has been with me throughout the work in India, has done his share both of the observations and of the computations to my entire satisfaction; the late Babu Shiv Nath Saha, Head Computer of the Trigonometrical Survey Office, on whom I have placed great reliance for many years, checked my figures; his successor Babu Ishan Chandra Dev, B.A., has made a great number of valuable suggestions and assisted by Babu Mukundananda Acharya has corrected all proofs.

In various parts of India I have been indebted to Officers of the Civil Service, of the Public Works Department, and of the Military Works Service and to others for the loan of rooms in which to erect the apparatus, and I have received much personal hospitality at their hands.

The list of those to whom my thanks are due would be a long one and I must confine myself to a general expression of gratitude for their many kindnesses.

December, 1908.

G. P. LENOX CONYNGHAM.

CHAPTER I.

The Pendulum Observations made at Kew and Greenwich Observatories in 1903.*

The pendulum observations of which an account is given in this Chapter had their origin in the decision of the Government of India to extend, with the aid of a new portable apparatus, the operations which were brought to a close in 1870.

Professor F. R. Helmert, Director of the Central Bureau of the International Geodetic Association, was asked for advice as to the form of apparatus to be acquired and he recommended the use of a half-seconds pendulum equipment as designed by Colonel von Sterneek. He further offered to obtain the instruments from Vienna, to have them fitted with the additions necessary for the determination of the flexure correction, to test the whole apparatus and to make determinations of the constants of the temperature and density corrections.

The India Office adopted Professor Helmert's suggestions and gratefully accepted the offer of his valuable assistance. The equipment was therefore ordered through the Geodetic Institute in Potsdam, where the observations for determining the instrumental constants were made by Professor L. Haasemann under Professor Helmert's direction.

In October 1902 Major Burrard and I happened to be on leave in England, and went to Potsdam in order to study the method of observing. We were most cordially received, and Professor Haasemann, who had had much experience in pendulum work, gave up the whole of his time to our instruction.

The apparatus was not quite complete at this time nor had the determinations of the constants been made, so at our departure we did not take the equipment with us, but left it to be sent over to England later on.

As the apparatus does not give the absolute value of the force of gravity, but only the difference from that at a Base station, the next step was to choose a Base and there swing the pendulums.

Kew Observatory was selected because it had been the Base Station of the earlier Indian series, and Dr. R. T. Glazebrook, F.R.S., Director of the National Physical Laboratory, most kindly gave his permission and promised all necessary assistance. Professor Helmert had asked that a fresh determination of the constants might be made at Kew as a check on the values obtained at Potsdam, and this also Dr. Glazebrook kindly undertook. In the meantime however the suggestion had been made by Mr. W. H. M. Christie, C.B., F.R.S., Astronomer Royal,

* An abridged account of these observations appeared in the *Proceedings of the Royal Society* —A. Vol. 78.

that the opportunity should be taken of making swings at Greenwich as well as at Kew so as to obtain a value of the difference in g at these observatories.

The Secretary of State for India sanctioned the addition of this work to the originally proposed standardisation and deputed Major Burrard and me to undertake it with the assistance of the Kew Staff.

The apparatus was made by E. Schneider of Vienna after Colonel von Sterneek's design. The pendulums are four in number, all of precisely similar appearance and with very nearly equal times of vibration. Their numbers are 137, 138, 139 and 140. They are made of brass heavily gilded, and have agate edges on which to vibrate; each has a small vertical mirror securely fastened to its head just above the line of these edges.

The stand on which the pendulums hang during the observation is solidly made of brass in the form of a truncated cone with three large apertures in the conical surface. It rests on three foot-screws which are capable of being firmly clamped. The stand carries a highly polished agate plane for the reception of the agate edges.

This plane is pierced by an oblong hole through which the head of the pendulum which is to be suspended is passed from underneath; after passage the pendulum is turned through a right angle so that the knife-edge bridging the hole, rests on the agate surface. In order to avoid accidental injury to the agates, such as might happen if the edges had to be placed on the plane by hand, the edges are divided into two portions, inner and outer, and stirrups are provided on which the operator places the latter in the first instance; then by the action of a slow-motion screw the stirrups are gently lowered from under the edges until the inner or true portions rest on the plane, the outer being entirely free.

In the base of the stand a lever is provided for starting the oscillation of the pendulum, it has an adjusting screw so that an oscillation of any desired amplitude can be imparted.

The pendulums swing in air at the natural pressure, but are protected by a cover from draughts.

The flash-box constitutes the other essential part of the equipment. It contains a contrivance whereby a shutter, moving up and down under the control of a break-circuit clock, allows a flash of light to pass through a slit at every beat or every alternate beat. This flash of light is reflected by the mirror on the vibrating pendulum into a small telescope fixed on the top of the flash-box; the times at which the flash passes the horizontal wire in the field of the telescope correspond to the coincidences of the free pendulum with the clock pendulum; the intervals between such passages are therefore the coincidence intervals of the pendulums.

The coincidence interval of each of the pendulums under discussion with that of a sidereal clock is about 35 sec. This is connected with the time of vibration by the equation

$$s = \frac{c}{2c - 1}$$

If $c = 35$ sec., $s = 0.507$ sec. approximately.

On the front of the flash-box there is a porcelain scale, graduated into divisions of 3 millimetres. By observing the reflection of this scale in the pendulum mirror and noting how many divisions pass over the central wire of the telescope as the pendulum vibrates, the amplitude of the vibration is determined, when the distance between the mirror and the scale is known. A convenient distance is about 2 metres and a convenient initial amplitude (semi-arc) of vibration is from 12 minutes to 20 minutes.

Besides the pendulum apparatus the equipment includes a clock with a half seconds pendulum, specially designed for portability. It has a convenient arrangement whereby the pendulum can be lifted from its bearings and clamped to the back of the case, so that it need not be taken off for a journey.

The clock.

The pendulum, made by Riefler of Munich, is of invar.

The break-circuit arrangement consists of a light lever fixed to one side of the clock case, which is lifted by a short arm on the pendulum as it approaches the end of its swing in that direction. The lever is adjustable so that the circuit may be broken for a longer or shorter fraction of a second at will.

The clock, made by Messrs. Strasser and Rohde of Glasshütte, is known as S.R. 238. This clock was not the only one used for timing the pendulums. Both at Kew and at Greenwich the standard clocks of the observatories were also connected to the flash-box, so that alternate observations could be made on each pendulum. In this paper the clock at Kew is called "Morrison 8702" and that at Greenwich "Sidereal Standard" or "S.S". Two break-circuit chronometers were most generously lent by Messrs. T. Mercer & Sons and by Mr. V. Kullberg respectively at a time when it was feared that S.R. 238 would not be ready.

That lent by Messrs. Mercer & Sons was used at Kew for two sets of observations.

The equipment includes two pairs of centigrade thermometers for the determination of the temperature inside the pendulum cover. The same pair was used both at Kew and at Greenwich, namely No. 105368 and No. 105369 by Negretti and Zambra.

Thermometers.

The degrees are divided on the scale into fifths, and they were read to fiftieths by estimation. The corrections of these thermometers were determined at the National Physical Laboratory both before and after the pendulum observations.

A barometer and hygrometer were lent by the National Physical Laboratory.

THE CORRECTIONS TO THE OBSERVED TIME OF VIBRATION.

The corrections are five in number, viz:—

1. Reduction to a vacuum.
2. „ a temperature of 0° C.
3. „ an infinitely small arc.
4. „ sidereal seconds.
5. „ a rigid pillar and stand.

The reduction to a vacuum, or correction for atmospheric density, is given by the expression

$$\text{Reduction to a vacuum.} \quad - \frac{k' (B + b) \left(1 - \frac{3}{8} \frac{e}{B}\right)}{760 + 2.79t}$$

where B = height of barometer in observing room,

b = reading of manometer attached to pendulum cover, (not used in these observations),

e = elastic force of aqueous vapour,

t = temperature inside the pendulum cover in degrees centigrade.

k' = a coefficient depending on the pendulum's shape, surface, etc.

The value of k' was carefully determined at Potsdam by Professor Haasemann. He had the advantage of possessing two complete sets of instruments, and was thus able to swing two pendulums simultaneously, timing both by the same clock, and so arranging the observations

as to cause the mean epochs of observation to coincide. The difference of the times of vibration thus obtained was free from the effect of unsteadiness in the rate of the clock.

From observations of all possible pairs of pendulums, under pressures varying from 350^{mm} to 1180^{mm} of mercury, he obtained equations whence the following results were deduced.

| | |
|--------------|--------------------|
| Pendulum 137 | $k' = 594 \pm 2.5$ |
| 138 | 572 ± 6.5 |
| 139 | 606 ± 1.0 |
| 140 | 606 ± 1.7 |
| Mean | $= 595$ |

In these numbers the unit is the 7th decimal place of a sidereal second.

The observations at Kew for the determination of k' were carried out by Mr. E. G. Constable.

No vacuum chamber had been supplied with the apparatus but one was specially made under Dr. Glazebrook's direction.

As only the one apparatus was available at Kew, consecutive observations of the same pendulum under different pressures had to be made and the clock's rate had to be considered invariable.

Observations were made at pressures of 395^{mm}, 585^{mm} and 775^{mm} and the results were as follows :—

| | |
|--------------|------------|
| Pendulum 137 | $k' = 605$ |
| 138 | 591 |
| 139 | 621 |
| 140 | 603 |
| Mean | $= 605$ |

Dr. Chree, who kindly reduced all the Kew observations, estimates that the error in the value of the constant for a single pendulum may not improbably amount to 2 or 3 per cent.

The Kew and Potsdam sets of values therefore agree as well as could be expected.

In the reduction of the pendulum observations, which follow, the Potsdam values have alone been used. This is due to the circumstance that the Kew observations were made later and were not available when the computations were being carried out.

No appreciable effect on the difference between the times of vibration of a pendulum at Kew and Greenwich respectively would be produced by a change of 10 per cent in k' , whereas here the difference between the means of the two sets is but 1.7 per cent.

The reduction to 0° Centigrade is sufficiently represented by the simple expression

Reduction to 0° Temp.

$$-kt^1$$

where t is the temperature of the pendulum during the observation and k a factor depending on its coefficient of expansion.

Determinations of k were made both at Potsdam and at Kew. At the former place Professor Haasemann again took advantage of his second apparatus, by comparing the time of vibration of each of the pendulums at different temperatures, with that of a reference pendulum which was swinging in an adjoining room where the temperature was nearly uniform. As before, the same clock was used for both pendulums and thus the results were freed from the effects of variable clock rate.

At Potsdam the pendulums were swung in a special case or chamber in which the temperature was artificially raised; at Kew the whole room in which the observations were made was heated.

At both places the pendulums were swung in air at the natural pressure.

At Potsdam observations were made at 3°C and 44°C approximately; at Kew the temperatures were 7°C, 20°C and 35°C.

The resulting values of k were as follows:—

| | Potsdam | Kew |
|--------------|----------------|------|
| Pendulum 137 | 49.2 \pm 0.1 | 48.9 |
| „ 138 | 48.9 \pm 0.2 | 50.8 |
| „ 139 | 49.1 \pm 0.2 | 48.2 |
| „ 140 | 48.9 \pm 0.1 | 49.6 |
| Mean | 49.0 | 49.4 |

The unit of these numbers is the 7th decimal place of a second of time.

The mean of the readings of two thermometers attached to the stand, the bulb of one being some distance above the middle of the pendulum's stem and that of the other an equal distance below it, was accepted as the temperature of the pendulum.

The thermometers used at Kew were not the same as those used at Potsdam, the latter being considerably smaller than the former; the close agreement between the results given above is some evidence, even if not very conclusive, that during the observations the temperature of the pendulum was well represented by the mean of the two thermometer readings.

The observation of each pendulum does not last longer than an hour and the decrease in arc between the beginning and end is not excessive; the reduction to an infinitely small arc. reduction to an infinitely small arc is therefore given with sufficient accuracy by the expression

$$-s \frac{a^2}{16}$$

where s = observed time of vibration
 a = mean semi-arc

Since the time of vibration = 0.507^s approximately, the correction to be applied on account of a clock rate of one second per diem is

Reduction to sidereal time.

$$\frac{1}{86.400} \times 0.507^s = 58.7^s \times 10^{-7}.$$

Several methods of determining the correction requisite to reduce the observed time of vibration to what it would have been on a perfectly rigid pillar and stand, have been devised.

Reduction to a rigid pillar.

In 1818 Kater, in a paper which he communicated to the Royal Society, alluded to the necessity of ascertaining that the stand on which his pendulum was swung was sensibly rigid; and the instrument which he employed for testing this consisted of a vertical rod, supported from below by a thin spring and carrying a moveable weight*. By adjusting the position of the weight the time of vibration of this inverted pendulum was made to coincide with that of the pendulum under observation, on the stand of which it was placed.

If the stand was being drawn to and fro by the swinging pendulum, even to a small extent, a visible vibration would in the course of a few minutes be set up, the amount of this induced vibration being a measure of the flexibility of the stand.

* A drawing of the instrument is to be found in Plate K.—III, Fig. 4, Vol. V of "*The Account of the Operations of the Great Trigonometrical Survey of India.*"

This idea has been gradually developed, and the apparatus which has been adopted for employment with this equipment is the latest form of device for giving effect to it. It is the invention of Professor R. Schumann of the Prussian Geodetic Institute. The necessary additions to the instrument to enable the method to be applied were made in Potsdam by Messrs. Töpfer & Sohn under Professor Helmert's direction.

The method may be described as follows :—

Two pendulums which vibrate in equal times are suspended on the same stand so that their planes of vibration coincide; both are carefully brought to rest and then one (which will be called the driving pendulum) is set swinging with a considerable amplitude. The rapidity with which the second (which will be called the driven pendulum) takes up the oscillation from the first is a measure of the flexibility of the pillar and stand; the correction to be applied to the time of vibration is deduced from the results of the observation. In order to shield the driven pendulum from the influence of the air set in motion by the driving pendulum a screen is placed between them.

By a theoretical analysis Professor Schumann shows that for a moderate time from the commencement of the oscillation (with these pendulums about 30 minutes), the ratio of the amplitude of the two pendulums increases as the time, the expression being

$$\frac{\phi}{\psi} = \frac{dl}{2l} \sqrt{\frac{g}{l}} \times t$$

where ϕ = amplitude of driven pendulum } at time t
 ψ = „ „ driving „ }
 dl = the small virtual increase in the length of the driving pendulum caused by the flexure of the stand.
 l = the length of the pendulum.

It is thus possible with a suitable apparatus to make observations whence dl can be deduced, and thence immediately the increase in the time of the pendulum's vibration due to the flexure of the stand.

Equality in the vibration periods of the two pendulums is one of the necessary conditions, and in practice it is found convenient to use as the driver an auxiliary pendulum, heavier than those of the original set of four and with an adjustable bob. The extra weight is to increase the effect on the driven pendulum and thus render it easier to measure, and the adjustability is to enable it to be used with any of the four invariable pendulums, or indeed with any pendulum whose period is about half a second.

In order to allow of the simultaneous suspension of two pendulums a strong bracket was fitted to the head of the stand, bearing agate planes for the reception of the driven pendulum: means of raising and lowering the pendulum without jarring its edges were provided. When both pendulums are suspended their knife-edges are in the same horizontal plane, parallel to each other and about 3 inches apart.

Fixed to the head of the driving pendulum is an arm, equal in length to this space, which carries at its end a vertical mirror; thus when this pendulum is resting on the central agate plane and the driven pendulum on the bracket their two mirrors are side by side.

The observation consists of simultaneously measuring the amplitudes of the oscillations of the two pendulums. This is done by observing the reflections of the scale fixed to the front of the flash-box. As the amplitudes of the oscillations never exceed 2° , and as their ratio only is required, it is sufficiently accurate to use the scale readings instead of computing the angles.

The observation proceeds as follows :—

When the driven pendulum has been carefully brought to rest in its natural position, the driver is set swinging through a suitable arc; the time at which the oscillation begins is

noted and two minutes are allowed to elapse before the observations commence. During the third minute the amplitude of the driver is first noted then that of the driven and then that of the driver again; thus the amplitudes at a common epoch, $2\frac{1}{2}$ minutes from the start, are measured: the fourth minute is allowed to pass, but during the fifth similar readings are made, and so on until eight sets have been recorded.

Eight values of the ratio $\frac{\phi}{\psi}$ have now been obtained, each of which would give a value of dl , but the expression connecting these quantities is based on the hypothesis that the driven pendulum is at perfect rest when the driver begins to oscillate, a condition which may not be satisfied. Prof. Schumann therefore puts $\frac{\phi}{\psi} = C + Dt$

$$\text{where } D = \frac{dl}{2l} \sqrt{\frac{g}{l}}$$

Hence, combining any two of the observations we have

$$\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1} = \frac{dl}{2l} \sqrt{\frac{g}{l}} \times (t_2 - t_1)$$

$$\text{and } dl = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times 2l \sqrt{\frac{l}{g}}$$

or, converting into terms of s the time of vibration common to both pendulums

$$dl = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times 2g \times \frac{s^3}{\pi^3}.$$

It is more convenient to find the increase in the time of vibration due to flexure than the virtual increase in the length of the pendulum,

$$\text{and as } \frac{ds}{dl} = \frac{1}{2} \frac{\pi}{\sqrt{gl}}$$

$$\text{we have } ds = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times \frac{s^2}{\pi}.$$

The extent to which the pillar yields is proportional to the horizontal pull of the knife-edge on the agate plane; therefore to obtain the quantity appropriate to the invariable pendulum, ds must be multiplied by a factor equal to the ratio of the moments of the invariable and auxiliary pendulums about their knife-edges. An empirical factor depending on the individual peculiarities of each pendulum,—difference in knife-edge etc.—was also sought for, but it was found that for pendulums of this form none is necessary.

The moments of the pendulums were not known but their ratio was determined by the following simple method: the pendulums, suspended as for the flexure observation, were brought to rest and readings of the reflected scales were taken with the telescope and recorded. A thread was then tied lightly round the stems of the pendulums so as to deflect them inwards from the vertical. If the pendulums be then brought to rest, and if the thread by which they are tied be horizontal, the angles through which they have respectively been deflected are in the inverse ratio of the moments about the points of suspension. If the observation of the reflect-

ed scales be now repeated the differences between the first and second sets of readings are measures of the angles of deflection, and the inverse ratio of these differences is equal to the required ratio of the moments. By a few repetitions of this process a sufficiently accurate value of the moment ratio can be obtained.

The four pendulums are so similar that in practice it is unnecessary to determine the flexure correction for each separately. The auxiliary pendulum was adjusted to swing isochronously with No. 137 and the latter has always been used for the flexure observation. The ratio of the moments of these two pendulums is 0.533.

The correction to the time of vibration of one of the invariable pendulums when swinging on the stand designed by Colonel von Sterneck—the stand being firmly clamped to a granite slab and the slab cemented to a solid masonry pillar some 20 inches high—is found to be about 38×10^{-7} . It varies slightly according to the tightness of the clamping and the quality of the pillar. 29×10^{-7} and 60×10^{-7} are the extreme values that have so far been found with this apparatus.

The probable error of a single determination is less than $\pm 1 \times 10^{-7}$, and that of the mean of four independent measures will not be larger than the probable error of other corrections.

The following is a specimen of the record of an observation for flexure and of the computation of the correction:—

Observation for Flexure.

Kew, October 16th, 1903. Observer E. G. Constable.

| Auxiliary Pendulum started at 36 ^m 20 ^s | | | | | | | | |
|---|-----------------------|--------------|--------------|----------------------|----------------------|----------------------|----------------|-------|
| No. | Pendulum | Time | | Scale Readings | | Amplitude | Mean Amplitude | Ratio |
| | | From | To | Above | Below | | | |
| 1 | Auxy: 137 Auxy: | m s 38 20 | m s 39 20 | 14.3 0.2 14.3 | 14.2 0.0 14.1 | 28.5 0.2 28.4 | 28.45 0.2 | .0070 |
| 2 | Auxy: 137 Auxy: | 40 20 | 41 20 | 14.0 0.3 14.1 | 13.8 0.2 13.7 | 27.8 0.5 27.8 | 27.8 0.5 | .0189 |
| 3 | Auxy: 137 Auxy: | 42 20 | 43 20 | 14.0 0.45 13.9 | 13.7 0.4 13.6 | 27.7 0.85 27.5 | 27.6 0.85 | .0308 |
| 4 | Auxy: 137 Auxy: | 44 20 | 45 20 | 13.7 0.55 13.7 | 13.4 0.5 13.4 | 27.1 1.05 27.1 | 27.1 1.05 | .0387 |
| 5 | Auxy: 137 Auxy: | 46 20 | 47 20 | 13.5 0.7 13.5 | 13.2 0.6 13.2 | 26.7 1.3 26.7 | 26.7 1.3 | .0487 |
| 6 | Auxy: 137 Auxy: | 48 20 | 49 20 | 13.3 0.8 13.2 | 13.1 0.8 13.0 | 26.4 1.6 26.2 | 26.3 1.6 | .0608 |
| 7 | Auxy: 137 Auxy: | 50 20 | 51 20 | 13.0 0.9 13.0 | 12.8 0.95 12.0 | 25.8 1.85 25.8 | 25.8 1.85 | .0717 |
| 8 | Auxy: 137 Auxy: | 52 20 | 53 20 | 12.8 1.0 12.8 | 12.6 1.0 12.5 | 25.4 2.0 25.3 | 25.35 2.0 | .0789 |

Computation of Flexure Correction.

| Numbers of the Observations | Difference of Ratios | Factor* | Flexure Correction |
|-----------------------------|----------------------|----------------------|-----------------------|
| 5-1 | ·0417 | 909×10^{-7} | 37.9×10^{-7} |
| 6-2 | ·0428 | „ | 38.9 |
| 7-3 | ·0409 | „ | 37.2 |
| 8-4 | ·0402 | „ | 36.5 |
| | | Mean ... | 37.6×10^{-7} |

For the determination of the value of g at any station the programme of observation of each pendulum consists of observing two series of 10 consecutive coincidences each, with an interval of 50 coincidences between the last coincidence of the first series and the first of the second series.

The coincidence observation. Ten values of a sixty-coincidence interval are thus obtained, from the mean of which a value of the time of vibration can be derived with a probable error not greater than that of the corrections for temperature flexure, etc.

Each pendulum was swung twice in 24 hours, intervals of 12 hours separating the swings, and it was assumed that the mean rate of the clock during the swings was equal to that deduced from star observations made at the same hour each evening.

The observations were usually made from 9 a.m. to 1 p.m. and from 9 p.m. to 1 a.m. the mean of the two constituting a determination of the time of vibration: a single observation was not considered of any value.

A copy of the record of an observation is given as an example.

Station Greenwich.

Date, 24th October 1903. Clock, S. R. 238. Pendulum 140. Observer E.G. Constable.

| Time | Barometer | | Hygrometer | | Arc | | Pendulum Thermometers | |
|---------------------|----------------------|-------------|-------------|-------------|-----------------|-----------------|-----------------------|------------------|
| | h | t | Dry | Wet | Above | Below | Upper No. 105368 | Lower No. 105369 |
| <i>h m</i> 10—10 | <i>in.</i> 29.727 | ° 48.6 F | ° 48.4 F | ° 45.4 F | <i>d</i> 5.7 | <i>d</i> 5.7 | ° 9.85 C | ° 9.90 C |
| 30 | ·728 | 48.7 | ·4 | ·4 | 4.7 | 4.7 | ·85 | ·90 |
| 59 | ·726 | 48.7 | ·4 | ·5 | 3.9 | 3.9 | ·85 | ·90 |
| MEANS ... | 29.727 | 48.7 | 48.4 | 45.4 | 4.8 | 4.8 | 9.85 | 9.90 |

$$* \text{ Factor} = \frac{s^2}{\pi (t_2 - t_1)} \times \frac{m s}{m' s'} = \frac{(0.507)^2}{3.1416 \times 480} \times 0.533 = 0.0000909, \quad t_2 - t_1 = 8 \text{ minutes.}$$

Coincidences.

| No. | Time | | | No. | Time | | | Difference | Remarks |
|-----|----------|----------|----------|-----------------------------|----------|----------|----------|-------------------|---------|
| | <i>h</i> | <i>m</i> | <i>s</i> | | <i>h</i> | <i>m</i> | <i>s</i> | <i>m</i> <i>s</i> | |
| 1 | 10 | 13 | 29.5 | 61 | 10 | 51 | 38.0 | 38 8.5 | |
| 2 | | 14 | 7.8 | 62 | | 52 | 16.2 | 8.4 | |
| 3 | | | 45.6 | 63 | | | 54.2 | 8.6 | |
| 4 | | 15 | 24.0 | 64 | | 53 | 32.5 | 8.5 | |
| 5 | | 16 | 2.0 | 65 | | 54 | 10.5 | 8.5 | |
| 6 | | | 40.4 | 66 | | | 48.8 | 8.4 | |
| 7 | | 17 | 18.3 | 67 | | 55 | 26.9 | 8.6 | |
| 8 | | | 56.5 | 68 | | 56 | 5.0 | 8.5 | |
| 9 | | 18 | 34.6 | 69 | | | 43.1 | 8.5 | |
| 10 | | 19 | 13.0 | 70 | | 57 | 21.3 | 8.3 | |
| 11 | | | 50.8 | | | | | | |
| | | | | MEAN ... 38 8.48 | | | | | |
| | | | | = Coincidence interval × 60 | | | | | |

DESCRIPTION OF STATIONS.

At Kew the pendulums were swung in the north room of the small house which lies to the west of the main building.

The pendulums oscillated in the plane of the prime vertical approximately, the shape of the room not permitting of their being swung in the meridian. This room had not before been used for pendulum observations. The rooms in the basement of the main building, which had been occupied by the various observers from 1864 to 1900, now contain the seismograph and are no longer available.

The new station is 100 feet 6 inches west of, 5 inches north of, and 6 feet 4 inches higher than that occupied by Mr. Constable in 1888 and by Mr. G. R. Putnam in 1900.

The co-ordinates of the new station are—

Latitude north ... 51° 28' 6".

Longitude west ... 0 18 48.

Height above mean sea level 23 feet.

At Greenwich the station was the same as that occupied by Colonel von Sterneck, Mr. Putnam, Mr. Hollis and others. It is situated in the record room about 20 yards to the east of the prime meridian.

The pendulums oscillated in the plane of the meridian.

The co-ordinates of the station are :—

Latitude north ... 51° 28' 38"

Longitude east ... 0 0 1

Height above mean sea level ... 155 feet.

Time signals were sent telegraphically every day from Greenwich Observatory to Kew at 10 a.m., and 1 p.m., and recorded on a chronograph at both places, so that the time of the signal in terms of the standard clock at each place could be read off.

The true sidereal time at which the signal was sent out from Greenwich was communicated by the Astronomer Royal as soon as the star observations had been reduced, and thus the error of the Kew standard clock (French) was ascertained.

Comparisons between "French" and the clocks used for the pendulum observations, viz:—Morrison 8702, S. R. 238 and Chronometer Mercer, were made by the method of coincidences using the comparing Chronometer Molyneux. These comparisons were made, by Mr. E. G. Constable, twice a day, soon after the time signals had been received from Greenwich.

For each night on which pendulum observations were made at Greenwich, the error of the sidereal standard clock as derived from the star observations, was furnished by the Astronomer Royal.

S. R. 238 was compared chronographically with the Sidereal Standard several times in the 24 hours and its daily rate was deduced from the results.

The Astronomer Royal kindly lent a very convenient chronograph for this purpose, and gave a permanent connection with the S.S. Clock, so that comparisons could be made at any time.

The following table shows the finally adopted clock rates on sidereal time for each period of 24 hours:—

Table I.

| Station | From | To | Rate in 24 hours; + = gaining; - = losing. | | | |
|-----------|-----------------|-----------------|--|----------------------------|--------|-----------|
| | | | Morrison 8702 | Chrono- meter Mercer | S.S. | S. R. 238 |
| Kew | 2 p.m. June 22 | 2 p.m. June 23 | - 0'30 | s | s | s |
| | " 23 | " 24 | - 0'32 | | | |
| | " 24 | " 25 | - 0'25 | | | |
| Kew | 2 p.m. Octr. 14 | 2 p.m. Octr. 15 | + 1'06 | + 1'53 | | |
| | " 15 | " 16 | + 1'05 | + 1'11 | | |
| Greenwich | 8 p.m. Octr. 20 | 8 p.m. Octr. 21 | | | - 0'06 | - 0'86 |
| | " 21 | " 22 | | | + 0'02 | - 0'82 |
| | " 22 | " 23 | | | - 0'07 | - 0'89 |
| | " 23 | " 24 | | | - 0'02 | - 0'87 |
| Kew | 2 p.m. Octr. 27 | 2 p.m. Octr. 28 | + 0'85 | | | - 4'90 |
| | " 28 | " 29 | + 1'00 | | | - 4'85 |
| | " 29 | " 30 | + 0'80 | | | - 5'00 |
| | " 30 | " 31 | + 0'80 | | | - 5'25 |

N.B.—Between June and October the clock Morrison 8702 underwent some alterations.

At Kew the extreme recorded temperatures inside the pendulum cover during a visit Temperature conditions. (3 to 5 days) differed by $2^{\circ}85$ C.

The extreme range during the observation of a set of pendulums (4 to 5 hours) was $1^{\circ}54$ C; and the average $0^{\circ}69$ C. This change was almost invariably an increase of temperature with the progress of the observation, occasionally it was fluctuating in character but usually fairly regular.

The extreme range during the observation of one pendulum (about 1 hour) was $0^{\circ}25$ C and the average $0^{\circ}07$ C, generally, but not invariably, an increase.

At Greenwich the extreme recorded temperatures during the visit differed by $2^{\circ}12$ C. The extreme range during a set of pendulums was $0^{\circ}49$ C with an average of $0^{\circ}21$ C, and the greatest range during the observation of one pendulum was $0^{\circ}25$ C with an average of $0^{\circ}06$ C. The superiority of the temperature conditions at Greenwich over those at Kew was due partly to the use of electric light in place of gas, and partly to the fact that the room was larger.

The results of the observations.

The results of the observations together with the reductions are exhibited in Table II.

In the column headed "observer" the initial B denotes Major S. G. Burrard, R.E., C denotes Mr. E. G. Constable and L. C. Major G. P. Lenox Conyngham, R.E.

A word of explanation as to the clocks used and the long interval separating the first observations at Kew from the remainder is called for.

In June 1903 when the observers arrived at Kew and wished to begin work, the clock (S.R.238) which had been ordered as part of the equipment had not been received from the makers, and for the first set of observations at Kew, Morrison 8702 was employed. While these observations were in progress the missing clock arrived, and when the observers moved to Greenwich they took it with them and erected it.

Two series of observations, one at Greenwich and one at Kew, were made with the aid of this clock, between June 29 and July 9, but were found, when reduced, to give very discordant and unsatisfactory results. Irregular clock rate seemed to be the source of evil and the clock was, at the makers' request, sent back for examination.

To reject all the observations made with this clock was the only course open. The Secretary of State for India was asked to sanction the repetition of the work and in October a new series was commenced. On this occasion it was determined, as a precaution, to supplement the observations by S.R.238 with separate timings of the pendulums by the clocks of the observatories, the use of which was kindly allowed by the Director of the National Physical Laboratory and the Astronomer Royal respectively. But again when the observers wished to begin, S. R. 238 had not arrived. Being unwilling to rely on one clock only they then sought the loan of a break circuit chronometer and both Messrs. Mercer & Co. and Messrs. Kulberg & Co. came forward in the most generous way. The observations at Kew from October 14th to 16th were made with the clock Morrison and the Chronometer Mercer, but as S.R.238 arrived on the 15th it was taken to Greenwich and used both there and on the return visit to Kew.

Early in October Major Burrard had to embark for India, so the observations of the second part of the work were made by Mr. Constable and Major Lenox Conyngham.

Table II. Pendulum Observations at Kew.

| Date | Time | Observer | Pendulum | Order of Observation | Coincidence Interval | | Mean Semi-Arc | Corrected Mean Temperature | Density of Air | Time of Vibration uncorrectd. | | Corrections on account of | | | | | Time of Vibration corrected | | | |
|---------------|-------|----------|----------|----------------------|----------------------|---------------------|---------------|----------------------------|----------------|-------------------------------|-----------------------|---------------------------|---------------|-----|-------------|----------------|-----------------------------|-----------------------|-----------------------|-----------------------|
| | | | | | Clock M. 8702 | Chron. Mercer | | | | Clock Morrison 8702 | Chron. Mercer | Clock Rate | | Arc | Temperature | Density of Air | Flexure | Clock Morrison 8702 | Chron. Mercer | Mean |
| | | | | | | | | | | | | M. 8702 | Chron. Mercer | | | | | | | |
| 1903 | | | | | | | | | | | | | | | | | | | | |
| Oct. 14 | Night | C | 137 | 1 | ^s 37°016 | ^s 37°025 | 10 | 14°18 | ·934 | ^s ·5068462 | ^s ·5068447 | -62 | -90 | -3 | -695 | -555 | -37 | ^s ·5067110 | ^s ·5067067 | ^s ·5067089 |
| | | L.C. | 138 | 3 | 35°803 | 35°765 | 11 | 14°71 | ·930 | ·5070815 | ·5070892 | 62 | 90 | 3 | 721 | 532 | 37 | ·5069460 | ·5069509 | ·5069485 |
| | | C | 139 | 2 | 37°566 | 37°531 | 10 | 14°45 | ·933 | ·5067447 | ·5067510 | 62 | 90 | 3 | 708 | 565 | 37 | ·5066072 | ·5066107 | ·5066090 |
| | | L.C. | 140 | 4 | 37°973 | 37°945 | 13 | 14°98 | ·928 | ·5066715 | ·5066763 | 62 | 90 | 5 | 734 | 562 | 37 | ·5065315 | ·5065335 | ·5065325 |
| Oct. 15 | Day | C | 137 | 1 | 37°117 | 37°049 | 12 | 13°87 | ·932 | ·5068275 | ·5068402 | 62 | 90 | 4 | 680 | 554 | 37 | ·5066938 | ·5067037 | ·5066988 |
| | | L.C. | 138 | 3 | 35°802 | 35°788 | 13 | 14°25 | ·933 | ·5070817 | ·5070847 | 62 | 90 | 5 | 698 | 534 | 37 | ·5069481 | ·5069483 | ·5069482 |
| | | C | 139 | 2 | 37°564 | 37°549 | 11 | 14°08 | ·934 | ·5067450 | ·5067479 | 62 | 90 | 3 | 690 | 566 | 37 | ·5066092 | ·5066093 | ·5066092 |
| | | L.C. | 140 | 4 | 37°984 | 37°965 | 12 | 14°50 | ·933 | ·5066695 | ·5066729 | 62 | 90 | 4 | 711 | 565 | 37 | ·5065316 | ·5065322 | ·5065319 |
| Mean Pendulum | | | | | | | | | | | | | | | | | | ·5066973 | ·5066994 | ·5066984 |
| Oct. 15 | Night | L.C. | 137 | 3 | 37°052 | 37°034 | 11 | 14°21 | ·938 | ·5068397 | ·5068429 | -62 | -65 | -3 | -696 | -557 | -37 | ·5067042 | ·5067071 | ·5067057 |
| | | C | 138 | 1 | 35°804 | 35°820 | 11 | 14°01 | ·939 | ·5070812 | ·5070781 | 62 | 65 | 3 | 686 | 537 | 37 | ·5069487 | ·5069453 | ·5069470 |
| | | L.C. | 139 | 4 | 37°574 | 37°549 | 12 | 14°23 | ·939 | ·5067432 | ·5067478 | 62 | 65 | 4 | 697 | 569 | 37 | ·5066063 | ·5066106 | ·5066084 |
| | | C | 140 | 2 | 37°993 | 37°979 | 11 | 14°22 | ·939 | ·5066680 | ·5066703 | 62 | 65 | 3 | 697 | 569 | 37 | ·5065312 | ·5065332 | ·5065322 |
| Oct. 16 | Day | L.C. | 137 | 3 | 37°075 | 37°070 | 11 | 12°98 | ·944 | ·5068353 | ·5068360 | 62 | 65 | 3 | 636 | 561 | 37 | ·5067054 | ·5067058 | ·5067056 |
| | | C | 138 | 1 | 35°838 | 35°847 | 11 | 12°43 | ·947 | ·5070746 | ·5070728 | 62 | 65 | 3 | 609 | 542 | 37 | ·5069493 | ·5069472 | ·5069482 |
| | | L.C. | 139 | 4 | 37°597 | 37°582 | 14 | 13°29 | ·941 | ·5067391 | ·5067417 | 62 | 65 | 5 | 651 | 570 | 37 | ·5066066 | ·5066089 | ·5066078 |
| | | C | 140 | 2 | 38°035 | 38°016 | 12 | 12°73 | ·946 | ·5066605 | ·5066638 | 62 | 65 | 4 | 624 | 573 | 37 | ·5065305 | ·5065335 | ·5065320 |
| Mean Pendulum | | | | | | | | | | | | | | | | | | ·5066978 | ·5066990 | ·5066984 |
| General Mean | | | | | | | | | | | | | | | | | | ·5066976 | ·5066992 | ·5066984 |

Table II. Pendulum Observations at Greenwich.

| Date | Time | Observer | Pendulum | Order of Observation | Coincidence Interval | | Mean Semi-Arc | Corrected Mean Temperature | Density of Air | Time of Vibration uncorrectd. | | Corrections on account of | | | | | Time of Vibration corrected | | | | |
|---------------|-------|----------|----------|----------------------|----------------------|---------------------|-----------------|----------------------------|----------------|-------------------------------|----------------------|---------------------------|-----------|-----|-------------|----------------|-----------------------------|-------------|----------------------|----------------------|----------------------|
| | | | | | Clock S. S. | Clock S. R. 238 | | | | Clock S. S. | Clock S. R. 238 | Clock Rate | | Arc | Temperature | Density of Air | Flexure | Clock S. S. | Clock S. R. 238 | Mean | |
| | | | | | | | | | | | | S. S. | S. R. 238 | | | | | | | | |
| 1903 | | | | | | | | | | | | | | | | | | | | | |
| Oct. 20 | Night | C | 137 | 1 | ^s 37.120 | ^s 37.139 | [°] 10 | 11.54 | .948 | ^s 5068270 | ^s 5068233 | + | 4 | +50 | -3 | -565 | -563 | -39 | ^s 5067104 | ^s 5067113 | ^s 5067109 |
| | | L.C. | 138 | 3 | 35.874 | 35.892 | 14 | 11.58 | .948 | 5070673 | 5070636 | 4 | 50 | 5 | 567 | 542 | 39 | 5069524 | 5069533 | 5069528 | |
| | | C | 139 | 2 | 37.635 | 37.663 | 10 | 11.52 | .948 | 5067322 | 5067272 | 4 | 50 | 3 | 564 | 574 | 39 | 5066146 | 5066142 | 5066144 | |
| | | L.C. | 140 | 4 | 38.062 | 38.080 | 13 | 11.63 | .947 | 5066558 | 5066526 | 4 | 50 | 5 | 570 | 574 | 39 | 5065374 | 5065388 | 5065381 | |
| Oct. 21 | Day | C | 137 | 1 | 37.117 | 37.137 | 11 | 11.64 | .947 | 5068275 | 5068237 | 4 | 50 | 3 | 570 | 563 | 39 | 5067104 | 5067112 | 5067108 | |
| | | C | 138 | 3 | 35.868 | 35.899 | 11 | 11.75 | .946 | 5070685 | 5070623 | 4 | 50 | 3 | 576 | 541 | 39 | 5069530 | 5069514 | 5069522 | |
| | | C | 139 | 2 | 37.631 | 37.666 | 12 | 11.72 | .946 | 5067329 | 5067267 | 4 | 50 | 4 | 574 | 573 | 39 | 5066143 | 5066127 | 5066135 | |
| | | C | 140 | 4 | 38.058 | 38.084 | 12 | 11.75 | .946 | 5066563 | 5066518 | 4 | 50 | 4 | 576 | 573 | 39 | 5065375 | 5065376 | 5065376 | |
| Mean Pendulum | | | | | | | | | | | | | | | | | | 5067038 | 5067038 | 5067038 | |
| Oct. 21 | Night | L.C. | 137 | 3 | 37.114 | 37.148 | 15 | 11.36 | .947 | 5068279 | 5068217 | - | 1 | +48 | -6 | -556 | -563 | -39 | 5067114 | 5067101 | 5067107 |
| | | L.C. | 138 | 1 | 35.877 | 35.911 | 14 | 11.41 | .947 | 5070665 | 5070599 | 1 | 48 | 5 | 559 | 542 | 39 | 5069519 | 5069502 | 5069511 | |
| | | L.C. | 139 | 4 | 37.637 | 37.665 | 16 | 11.31 | .948 | 5067318 | 5067268 | 1 | 48 | 7 | 554 | 574 | 39 | 5066143 | 5066142 | 5066142 | |
| | | L.C. | 140 | 2 | 38.052 | 38.097 | 13 | 11.40 | .947 | 5066575 | 5066495 | 1 | 48 | 5 | 558 | 574 | 39 | 5065398 | 5065367 | 5065383 | |
| Oct. 22 | Day | C | 137 | 3 | 37.125 | 37.153 | 12 | 11.24 | .939 | 5068259 | 5068208 | 1 | 48 | 4 | 551 | 558 | 39 | 5067106 | 5067104 | 5067105 | |
| | | C | 138 | 1 | 35.873 | 35.900 | 10 | 11.04 | .941 | 5070675 | 5070621 | 1 | 48 | 3 | 541 | 538 | 39 | 5069553 | 5069548 | 5069551 | |
| | | L.C. | 139 | 4 | 37.639 | 37.675 | 13 | 11.41 | .936 | 5067315 | 5067249 | 1 | 48 | 5 | 559 | 567 | 39 | 5066144 | 5066127 | 5066135 | |
| | | C | 140 | 2 | 38.080 | 38.102 | 12 | 11.12 | .939 | 5066526 | 5066487 | 1 | 48 | 4 | 545 | 569 | 39 | 5065368 | 5065378 | 5065373 | |
| Mean Pendulum | | | | | | | | | | | | | | | | | | 5067043 | 5067034 | 5067038 | |
| Oct. 22 | Night | C | 137 | 2 | 37.127 | 37.164 | 12 | 11.12 | .938 | 5068257 | 5068188 | + | 4 | +52 | -4 | -545 | -557 | -39 | 5067116 | 5067095 | 5067106 |
| | | L.C. | 138 | 4 | 35.884 | 35.906 | 14 | 11.15 | .939 | 5070653 | 5070608 | 4 | 52 | 5 | 546 | 537 | 39 | 5069530 | 5069533 | 5069531 | |
| | | C | 139 | 1 | 37.651 | 37.683 | 9 | 11.07 | .938 | 5067295 | 5067235 | 4 | 52 | 2 | 542 | 568 | 39 | 5066148 | 5066136 | 5066142 | |
| | | L.C. | 140 | 3 | 38.075 | 38.098 | 14 | 11.11 | .939 | 5066535 | 5066493 | 4 | 52 | 5 | 544 | 569 | 39 | 5065382 | 5065388 | 5065385 | |
| Oct. 23 | Day | C | 137 | 2 | 37.148 | 37.174 | 12 | 10.57 | .944 | 5068216 | 5068168 | 4 | 52 | 4 | 518 | 561 | 39 | 5067098 | 5067098 | 5067098 | |
| | | L.C. | 138 | 4 | 35.894 | 35.919 | 15 | 10.71 | .942 | 5070632 | 5070583 | 4 | 52 | 6 | 526 | 539 | 39 | 5069527 | 5069526 | 5069526 | |
| | | C | 139 | 1 | 37.659 | 37.693 | 12 | 10.47 | .944 | 5067279 | 5067218 | 4 | 52 | 4 | 513 | 572 | 39 | 5066155 | 5066142 | 5066149 | |
| | | C | 140 | 3 | 38.091 | 38.119 | 12 | 10.67 | .942 | 5066506 | 5066457 | 4 | 52 | 4 | 523 | 571 | 39 | 5065373 | 5065372 | 5065373 | |
| Mean Pendulum | | | | | | | | | | | | | | | | | | 5067041 | 5067036 | 5067039 | |

Table II. Pendulum Observations at Greenwich.

| Date | Time | Observer | Pendulum | Order of Observation | Coincidence Interval | | Mean Semi-Arc | Corrected Mean Temperature | Density of Air | Time of Vibration uncorrtd. | | Corrections on account of | | | | | Time of Vibration corrected | | | | |
|-----------------|---------------|----------|----------|----------------------|----------------------|-----------------|---------------|----------------------------|----------------|-----------------------------|-----------------|---------------------------|-----------|-----|-------------|----------------|-----------------------------|-------------|-----------------|---------|---------|
| | | | | | Clock S. S. | Clock S. R. 238 | | | | Clock S. S. | Clock S. R. 238 | Clock Rate | | Arc | Temperature | Density of Air | Flexure | Clock S. S. | Clock S. R. 238 | Mean | |
| | | | | | | | | | | | | S. S. | S. R. 238 | | | | | | | | |
| 1903 Oct. 23 | Night | L. C. | 137 | 4 | 37.141 | 37.167 | 12 | 10.52 | .954 | 5068230 | 5068183 | + | 1 | +51 | -4 | -515 | -567 | -39 | 5067106 | 5067109 | 5067107 |
| | | C | 138 | 2 | 35.889 | 35.917 | 13 | 10.72 | .949 | 5070643 | 5070586 | 1 | 51 | 5 | 526 | 543 | 39 | 5069532 | 5069525 | 5069529 | |
| | | L. C. | 139 | 3 | 37.657 | 37.688 | 14 | 10.58 | .952 | 5067282 | 5067227 | 1 | 51 | 5 | 518 | 577 | 39 | 5066144 | 5066139 | 5066141 | |
| | | C | 140 | 1 | 38.085 | 38.117 | 13 | 10.66 | .949 | 5066516 | 5066460 | 1 | 51 | 5 | 522 | 575 | 39 | 5065376 | 5065370 | 5065373 | |
| | Day | L. C. | 137 | 4 | 37.150 | 37.187 | 15 | 10.22 | .952 | 5068215 | 5068145 | 1 | 51 | 6 | 501 | 565 | 39 | 5067105 | 5067085 | 5067095 | |
| | | C | 138 | 2 | 35.917 | 35.950 | 12 | 9.88 | .958 | 5070587 | 5070521 | 1 | 51 | 4 | 484 | 548 | 39 | 5069513 | 5069497 | 5069505 | |
| | | C | 139 | 3 | 37.669 | 37.710 | 14 | 10.01 | .954 | 5067261 | 5067187 | 1 | 51 | 5 | 490 | 578 | 39 | 5066150 | 5066126 | 5066138 | |
| | | C | 140 | 1 | 38.154 | 38.141 | 11 | 9.73 | .958 | 5066393 | 5066415 | 1 | 51 | 3 | 477 | 581 | 39 | 5065264 | 5065366 | 5065330 | |
| | Mean Pendulum | | | | | | | | | | | | | | | | | 5067028 | 5067027 | 5067027 | |
| | General Mean | | | | | | | | | | | | | | | | | 5067037 | 5067034 | 5067036 | |

Table II. Pendulum Observations at Kew.

| Date | Time | Observer | Pendulum | Order of Observation | Coincidence Interval | | Mean Semi-Arc | Corrected Mean Temperature | Density of Air | Time of Vibration uncorrectd. | | Corrections on account of | | | | | Time of Vibration corrected | | | | | |
|---------------|---------------|----------|----------|----------------------|----------------------|----------------------|----------------------|----------------------------|---------------------|-------------------------------|---------------------|---------------------------|---------|-----|-------------|----------------|-----------------------------|-----------|---------------|---------|---------|---------|
| | | | | | Clock S. R. 238 | Clock Morrison 8702 | | | | Clock S. R. 238 | Clock Morrison 8702 | Clock Rate | | Arc | Temperature | Density of Air | Flexure | S. R. 238 | Morrison 8702 | Mean | | |
| | | | | | | | | | | | | S. R. 238 | M. 8702 | | | | | | | | | |
| 1903 | Oct. 27 | Night | C | 137 | 1 | 37 ^s .275 | 37 ^s .095 | 11 | 12 ^o .62 | .923 | 5067981 | 5068316 | +288 | -50 | -3 | -618 | -548 | -45 | 5067055 | 5067052 | 5067054 | |
| | | | L.C. | 138 | 3 | 35 ^s .998 | 35 ^s .828 | 14 | 13 ^o .60 | .920 | 5070427 | 5060765 | 288 | 50 | 5 | 666 | 526 | 45 | 5069473 | 5069473 | 5069473 | |
| | | C | 139 | 2 | 37 ^s .789 | 37 ^s .598 | 12 | 12 ^o .87 | .922 | 5067045 | 5067388 | 288 | 50 | 4 | 631 | 559 | 45 | 5066094 | 5066099 | 5066096 | | |
| | | | L.C. | 140 | 4 | 38 ^s .185 | 37 ^s .998 | 15 | 13 ^o .73 | .918 | 5066340 | 5066670 | 288 | 50 | 6 | 673 | 556 | 45 | 5065348 | 5065340 | 5065344 | |
| | Oct. 28 | Day | C | 137 | 1 | 37 ^s .258 | 37 ^s .042 | 11 | 12 ^o .84 | .921 | 5068012 | 5068415 | 288 | 50 | 3 | 629 | 547 | 45 | 5067076 | 5067141 | 5067109 | |
| | | | L.C. | 138 | 3 | 36 ^s .004 | 35 ^s .831 | 13 | 13 ^o .23 | .926 | 5070415 | 5070759 | 288 | 50 | 5 | 648 | 530 | 45 | 5069475 | 5069481 | 5069478 | |
| | | | C | 139 | 2 | 37 ^s .780 | 37 ^s .590 | 11 | 12 ^o .97 | .925 | 5067059 | 5067405 | 288 | 50 | 3 | 636 | 561 | 45 | 5066102 | 5066110 | 5066106 | |
| | | | L.C. | 140 | 4 | 38 ^s .193 | 38 ^s .003 | 14 | 13 ^o .38 | .926 | 5066325 | 5066661 | 288 | 50 | 5 | 656 | 561 | 45 | 5065346 | 5065344 | 5065345 | |
| | Mean Pendulum | | | | | | | | | | | | | | | | | 5066996 | 5067005 | 5067001 | | |
| | Oct. 28 | Night | L.C. | 137 | 3 | 37 ^s .237 | 37 ^s .060 | 14 | 13 ^o .42 | .932 | 5068051 | 5068381 | +285 | -59 | -5 | -658 | -554 | -45 | 5067074 | 5067060 | 5067067 | |
| | | | C | 138 | 1 | 36 ^s .009 | 35 ^s .835 | 13 | 13 ^o .02 | .935 | 5070407 | 5070753 | 285 | 59 | 5 | 638 | 535 | 45 | 5069469 | 5069471 | 5069470 | |
| | | | L.C. | 139 | 4 | 37 ^s .760 | 37 ^s .580 | 15 | 13 ^o .54 | .931 | 5067097 | 5067422 | 285 | 59 | 6 | 663 | 561 | 45 | 5066104 | 5066085 | 5066095 | |
| | | | C | 140 | 2 | 38 ^s .201 | 38 ^s .007 | 14 | 13 ^o .23 | .935 | 5066310 | 5066653 | 285 | 59 | 5 | 648 | 567 | 45 | 5065330 | 5065329 | 5065329 | |
| | | Oct. 29 | Day | L.C. | 137 | 3 | 37 ^s .257 | 37 ^s .066 | 14 | 13 ^o .22 | .936 | 5068013 | 5068372 | 285 | 59 | 5 | 648 | 556 | 45 | 5067044 | 5067059 | 5067052 |
| | | | | C | 138 | 1 | 36 ^s .027 | 35 ^s .857 | 12 | 12 ^o .48 | .941 | 5070368 | 5070708 | 285 | 59 | 4 | 612 | 538 | 45 | 5069454 | 5069450 | 5069452 |
| | | | | L.C. | 139 | 4 | 37 ^s .784 | 37 ^s .577 | 17 | 13 ^o .32 | .935 | 5067052 | 5067428 | 285 | 59 | 8 | 653 | 567 | 45 | 5066064 | 5066096 | 5066080 |
| | | | | C | 140 | 2 | 38 ^s .221 | 38 ^s .020 | 12 | 12 ^o .79 | .937 | 5066277 | 5066631 | 285 | 59 | 4 | 627 | 568 | 45 | 5065318 | 5065328 | 5065323 |
| | Mean Pendulum | | | | | | | | | | | | | | | | | 5066982 | 5066985 | 5066984 | | |
| Oct. 29 | Night | C | 137 | 2 | 37 ^s .237 | 37 ^s .059 | 14 | 13 ^o .46 | .936 | 5068051 | 5068382 | +294 | -47 | -5 | -660 | -556 | -45 | 5067079 | 5067069 | 5067074 | | |
| | | L.C. | 138 | 4 | 35 ^s .974 | 35 ^s .816 | 14 | 14 ^o .01 | .934 | 5070473 | 5070788 | 294 | 47 | 5 | 686 | 534 | 45 | 5069497 | 5069471 | 5069484 | | |
| | | C | 139 | 1 | 37 ^s .760 | 37 ^s .574 | 14 | 13 ^o .38 | .937 | 5067095 | 5067433 | 294 | 47 | 5 | 656 | 568 | 45 | 5066115 | 5066112 | 5066114 | | |
| | | L.C. | 140 | 3 | 38 ^s .184 | 38 ^s .001 | 12 | 13 ^o .81 | .935 | 5066341 | 5066663 | 294 | 47 | 4 | 677 | 567 | 45 | 5065342 | 5065323 | 5065332 | | |
| | Oct. 30 | Day | C | 137 | 2 | 37 ^s .261 | 37 ^s .074 | 14 | 12 ^o .94 | .945 | 5068008 | 5068356 | 294 | 47 | 5 | 634 | 561 | 45 | 5067057 | 5067064 | 5067061 | |
| | | | L.C. | 138 | 4 | 35 ^s .990 | 35 ^s .823 | 13 | 13 ^o .44 | .944 | 5070443 | 5070776 | 294 | 47 | 5 | 659 | 540 | 45 | 5069488 | 5069480 | 5069484 | |
| | | | C | 139 | 1 | 37 ^s .780 | 37 ^s .590 | 14 | 12 ^o .72 | .946 | 5067060 | 5067402 | 294 | 47 | 5 | 623 | 573 | 45 | 5066108 | 5066109 | 5066108 | |
| | | | L.C. | 140 | 3 | 38 ^s .207 | 38 ^s .015 | 15 | 13 ^o .18 | .945 | 5066301 | 5066640 | 294 | 47 | 6 | 646 | 573 | 45 | 5065325 | 5065323 | 5065324 | |
| Mean Pendulum | | | | | | | | | | | | | | | | | 5067001 | 5066994 | 5066998 | | | |

Table II. *Pendulum Observations at Kew.*

| Date | Time | Observer | Pendulum | Order of Observation | Coincidence Interval | | Mean Semi-Arc | Corrected Mean Temperature | Density of Air | Time of Vibration uncorrected. | | Corrections on account of | | | | | | Time of Vibration corrected | | | |
|---------------|-------|----------|----------|----------------------|----------------------|----------------------|---------------|----------------------------|----------------|--------------------------------|---------------------|---------------------------|---------|-----|-------------|----------------|---------|-----------------------------|---------------|----------|--|
| | | | | | Clock S. R. 238 | Clock Morrison 7802 | | | | Clock S. R. 238 | Clock Morrison 8702 | Clock Rate | | Arc | Temperature | Density of Air | Flexure | S. R. 238 | Morrison 8702 | Mean | |
| | | | | | | | | | | | | S. R. 238 | M. 8702 | | | | | | | | |
| 1903 | | | | | | | | | | | | | | | | | | | | | |
| Oct. 30 | Night | L. C. | 137 | 4 | 37 ^s .239 | 37 ^s .061 | 14 | 13°31' | .950 | .5068049 | .5068379 | +308 | -47 | -5 | -652 | -564 | -45 | .5067091 | .5067066 | .5067079 | |
| | | C | 138 | 2 | 35 ^s .998 | 35 ^s .830 | 15 | 13°01' | .950 | .5070428 | .5070762 | 308 | 47 | 6 | 637 | 543 | 45 | .5069505 | .5069484 | .5069494 | |
| | | L. C. | 139 | 3 | 37 ^s .772 | 37 ^s .589 | 15 | 13°21' | .950 | .5067076 | .5067405 | 308 | 47 | 6 | 647 | 576 | 55 | .5066110 | .5066084 | .5066097 | |
| | | C | 140 | 1 | 38 ^s .204 | 38 ^s .009 | 15 | 12°91' | .950 | .5066307 | .5066652 | 308 | 47 | 6 | 633 | 576 | 45 | .5065355 | .5065345 | .5065350 | |
| Oct. 31 | Day | L. C. | 137 | 4 | 37 ^s .292 | 37 ^s .098 | 15 | 11°89' | .956 | .5067950 | .5068309 | 308 | 47 | 6 | 583 | 568 | 45 | .5067056 | .5067060 | .5067058 | |
| | | C | 138 | 2 | 36 ^s .052 | 35 ^s .870 | 11 | 11°30' | .960 | .5070320 | .5070679 | 308 | 47 | 3 | 554 | 549 | 45 | .5069477 | .5069481 | .5069479 | |
| | | C | 139 | 3 | 37 ^s .832 | 37 ^s .631 | 12 | 11°58' | .958 | .5066967 | .5067331 | 308 | 47 | 4 | 567 | 581 | 45 | .5066078 | .5066087 | .5066083 | |
| | | C | 140 | 1 | 38 ^s .268 | 38 ^s .071 | 12 | 11°19' | .961 | .5066192 | .5066541 | 308 | 47 | 4 | 548 | 582 | 45 | .5065321 | .5065315 | .5065318 | |
| Mean Pendulum | | | | | | | | | | | | | | | | | | .5066999 | .5066990 | .5066993 | |
| General Mean | | | | | | | | | | | | | | | | | | .5066995 | .5066994 | .5066994 | |

In Table III the results obtained in Table II are arranged so as to show the behaviour of the individual pendulums.

Table III.—*Time of Vibration.*

Kew. (First Visit).

Determination A.

| Clock | Morrison 8702 | | | |
|----------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Pendulum | 137 | 138 | 139 | 140 |
| June 22 night ,, 23 day | ^s 0·5067098 ·5067084 | ^s 0·5069519 ·5069506 | ^s 0·5066108 ·5066096 | ^s 0·5065341 ·5065361 |
| Mean ... | ·5067091 | ·5069513 | ·5066102 | ·5065351 |
| June 23 night ,, 24 day | ·5067065 ·5067083 | ·5069493 ·5069508 | ·5066106 ·5066117 | ·5065339 ·5065355 |
| Mean ... | ·5067074 | ·5069500 | ·5066112 | ·5065347 |
| June 24 night ,, 25 day | ·5067082 ·5067083 | ·5069515 ·5069513 | ·5066114 ·5066123 | ·5065342 ·5065344 |
| Mean ... | ·5067083 | ·5069514 | ·5066118 | ·5065343 |
| Mean of each Pendulum | ·5067083 | ·5069509 | ·5066111 | ·5065347 |
| GENERAL MEAN | ^s 0·5067012 | | | |
| Differences from Mean | + 71 | + 2497 | - 901 | - 1665 |

Kew. (Second Visit).

Determination B.

Determination C.

| Clock | Morrison 8702 | | | | Chronometer Mercer | | | |
|----------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Pendulum | 137 | 138 | 139 | 140 | 137 | 138 | 139 | 140 |
| Oct. 14 night ,, 15 day | ^s 0.5067110 .5066938 | ^s 0.5069460 .5069481 | ^s 0.5066072 .5066092 | ^s 0.5065315 .5065316 | ^s 0.5067067 .5067037 | ^s 0.5069509 .5069483 | ^s 0.5066107 .5066093 | ^s 0.5065335 .5065322 |
| Mean ... | .5067024 | .5069471 | .5066082 | .5065315 | .5067052 | .5069496 | .5066100 | .5065329 |
| Oct. 15 night ,, 16 day | .5067042 .5067054 | .5069487 .5069493 | .5066063 .5066066 | .5065312 .5065305 | .5067071 .5067058 | .5069453 .5069472 | .5066106 .5066089 | .5065332 .5065335 |
| Mean ... | .5067048 | .5069490 | .5066065 | .5065309 | .5067064 | .5069463 | .5066097 | .5065334 |
| Mean of each Pendulum | .5067036 | .5069481 | .5066073 | .5065312 | .5067058 | .5069480 | .5066099 | .5065331 |
| GENERAL MEAN | ^s 0.5066976 | | | | ^s 0.5066992 | | | |
| Differences from Mean | + 60 | + 2505 | - 903 | - 1664 | + 66 | + 2488 | - 893 | - 1661 |

Kew (Third Visit).

Determination D.

Determination E.

| Clock | S. R. 238 | | | | Morrison 8702 | | | |
|----------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Pendulum | 137 | 138 | 139 | 140 | 137 | 138 | 139 | 140 |
| Oct. 27 night ,, 28 day | ^s 0.5067055 .5067076 | ^s 0.5069473 .5069475 | ^s 0.5066094 .5066102 | ^s 0.5065348 .5065346 | ^s 0.5067052 .5067141 | ^s 0.5069473 .5069481 | ^s 0.5066099 .5066110 | ^s 0.5065340 .5065344 |
| Mean ... | .5067066 | .5069474 | .5066098 | .5065347 | .5067097 | .5069477 | .5066104 | .5065342 |
| Oct. 28 night ,, 29 day | .5067074 .5067044 | .5069469 .5069454 | .5066104 .5066064 | .5065330 .5065318 | .5067060 .5067059 | .5069471 .5069450 | .5066085 .5066096 | .5065329 .5065328 |
| Mean ... | .5067059 | .5069462 | .5066084 | .5065324 | .5067060 | .5069460 | .5066091 | .5065328 |
| Oct. 29 night ,, 30 day | .5067079 .5067057 | .5069497 .5069488 | .5066115 .5066108 | .5065342 .5065325 | .5067069 .5067064 | .5069471 .5069480 | .5066112 .5066109 | .5065323 .5065323 |
| Mean ... | .5067068 | .5069493 | .5066111 | .5065334 | .5067066 | .5069476 | .5066110 | .5065323 |
| Oct. 30 night ,, 31 day | .5067091 .5067056 | .5069505 .5069477 | .5066110 .5066078 | .5065355 .5065321 | .5067066 .5067060 | .5069484 .5069481 | .5066084 .5066087 | .5065345 .5065315 |
| Mean ... | .5067074 | .5069491 | .5066094 | .5065338 | .5067063 | .5069483 | .5066085 | .5065330 |
| Mean of each Pendulum | .5067067 | .5069480 | .5066097 | .5065336 | .5067071 | .5069474 | .5066098 | .5065331 |
| GENERAL MEAN | ^s 0.5066995 | | | | ^s 0.5066994 | | | |
| Differences from Mean | + 72 | + 2485 | - 898 | - 1659 | + 77 | + 2480 | - 896 | - 1663 |

Table III.—Time of Vibration.

Greenwich.

Determination A.

Determination B.

| Clock | Sidereal Standard | | | | S. R. 238 | | | |
|-----------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Pendulum | 137 | 138 | 139 | 140 | 137 | 138 | 139 | 140 |
| Oct. 20 night | ^s 0.5067104 | ^s 0.5069524 | ^s 0.5066146 | ^s 0.5065374 | ^s 0.5067113 | ^s 0.5069533 | ^s 0.5066142 | ^s 0.5065388 |
| „ 21 day | 0.5067104 | 0.5069530 | 0.5066143 | 0.5065375 | 0.5067112 | 0.5069514 | 0.5066127 | 0.5065376 |
| Mean | 0.5067104 | 0.5069527 | 0.5066145 | 0.5065374 | 0.5067113 | 0.5069523 | 0.5066135 | 0.5065382 |
| Oct. 21 night | 0.5067114 | 0.5069519 | 0.5066143 | 0.5065398 | 0.5067101 | 0.5069502 | 0.5066142 | 0.5065367 |
| „ 22 day | 0.5067106 | 0.5069553 | 0.5066144 | 0.5065368 | 0.5067104 | 0.5069548 | 0.5066127 | 0.5065378 |
| Mean | 0.5067110 | 0.5069536 | 0.5066144 | 0.5065383 | 0.5067102 | 0.5069525 | 0.5066135 | 0.5065372 |
| Oct. 22 night | 0.5067116 | 0.5069530 | 0.5066148 | 0.5065382 | 0.5067095 | 0.5069533 | 0.5066136 | 0.5065388 |
| „ 23 day | 0.5067098 | 0.5069527 | 0.5066155 | 0.5065373 | 0.5067098 | 0.5069526 | 0.5066142 | 0.5065372 |
| Mean | 0.5067107 | 0.5069529 | 0.5066151 | 0.5065378 | 0.5067097 | 0.5069529 | 0.5066139 | 0.5065380 |
| Oct. 23 night | 0.5067106 | 0.5069532 | 0.5066144 | 0.5065376 | 0.5067109 | 0.5069525 | 0.5066139 | 0.5065370 |
| „ 24 day | 0.5067105 | 0.5069513 | 0.5066150 | 0.5065294 | 0.5067085 | 0.5069497 | 0.5066126 | 0.5065366 |
| Mean | 0.5067106 | 0.5069522 | 0.5066147 | 0.5065335 | 0.5067097 | 0.5069511 | 0.5066133 | 0.5065368 |
| Mean of each Pendulum | 0.5067107 | 0.5069529 | 0.5066147 | 0.5065368 | 0.5067102 | 0.5069522 | 0.5066136 | 0.5065375 |
| GENERAL MEAN | ^s 0.5067038 | | | | ^s 0.5067034 | | | |
| Differences from Mean | + 69 | + 2491 | - 891 | - 1670 | + 68 | + 2488 | - 898 | - 1659 |

In the computation of Tables II & III the temperature of the pendulums has been assumed equal to the mean of the readings of the thermometers. This assumption may be legitimate when the temperature of the air is steady, but when the latter is rising or falling the pendulums will unquestionably lag behind the thermometers in taking up the change, and consequently a further correction depending on the temperature gradient, will be required.

This correction may be called either the "lag" correction, or the "dynamical" temperature correction.

No experiments have as yet been made to determine the amount of this correction in the case of these pendulums, but with an almost identical apparatus belonging to the Prussian Geodetic Institute it was found to be 25×10^{-7} for a rate of change of temperature of 1° C. per hour.

To obtain a view of the march of temperature during each of the sets of observations, and of the consequent lag correction, Table IV has been drawn up. In the column headed "mean temperatures" are shown, firstly, the mean of the temperatures of the first two pendulums of a set, and, secondly, that of the last two. (It is to be noted that in Table II, whence the temperatures are taken, the pendulums are entered in numerical order; the order of observation in the set is shown in the column to the right of the distinguishing numbers: thus 137. 3. means that No. 137 was observed third). The sign of the correction is easily understood when it is considered that with a rising temperature the pendulums are cooler than the thermometer readings would lead one to suppose.

Table IV. Showing change of temperature during an observation of the pendulums and the deduced correction on account of the lag of the pendulums on the thermometers.

| Station | Date | | | Time | Mean Temperature | Change | Interval | Correction | |
|-----------|---------|---------|-------|-------------|-----------------------|---------------------|------------|------------|-------|
| Kew | June | 22 | night | h 15.2 | $^{\circ}$ 15.15 O | $^{\circ}$ | h | | |
| | | | " | 17.8 | 15.77 | +0.62 | 2.6 | + 6.0 | |
| | " | 23 | day | 3.7 | 14.62 | | | | |
| | | | " | 6.4 | 15.61 | +0.99 | 2.7 | + 9.2 | |
| | " | " | night | 15.5 | 16.14 | | | | |
| | | | " | 17.9 | 16.37 | +0.23 | 2.4 | + 2.4 | |
| | " | 24 | day | 3.5 | 15.68 | | | | |
| | | | " | 6.3 | 16.32 | +0.64 | 2.8 | + 5.7 | |
| Kew | " | " | night | 15.8 | 16.44 | | | | |
| | | | " | 18.0 | 16.45 | +0.01 | 2.2 | + 0.1 | |
| | " | 25 | day | 3.7 | 15.85 | | | | |
| | | | " | 5.8 | 16.03 | +0.18 | 2.1 | + 2.1 | |
| | Mean | | | | | | | + 4.3 | |
| | Kew | October | 14 | night | h 22.5 | $^{\circ}$ 14.32 | $^{\circ}$ | h | |
| | | | | " | 1.2 | 14.84 | +0.52 | 2.7 | + 4.8 |
| | | " | 15 | day | 11.0 | 13.98 | | | |
| | | | " | 13.6 | 14.38 | +0.40 | 2.6 | + 3.8 | |
| " | | " | night | 22.5 | 14.12 | | | | |
| | | | " | 1.2 | 14.22 | +0.10 | 2.7 | + 0.9 | |
| " | | 16 | day | 11.0 | 12.58 | | | | |
| | | | " | 13.7 | 13.14 | +0.56 | 2.7 | + 5.2 | |
| Mean | | | | | | | + 3.7 | | |
| Greenwich | October | 20 | night | h 23.0 | $^{\circ}$ 11.53 | $^{\circ}$ | h | | |
| | | | " | 1.7 | 11.61 | +0.08 | 2.7 | +0.7 | |
| | " | 21 | day | 11.2 | 11.68 | | | | |
| | | | " | 13.8 | 11.75 | +0.07 | 2.6 | +0.7 | |
| | " | " | night | 23.7 | 11.41 | | | | |
| | | | " | 2.2 | 11.34 | -0.07 | 2.5 | -0.7 | |
| | " | 22 | day | 11.3 | 11.08 | | | | |
| | | | " | 14.0 | 11.33 | +0.25 | 2.7 | +2.3 | |
| | " | " | night | 23.1 | 11.10 | | | | |
| | | | " | 2.1 | 11.13 | +0.03 | 3.0 | +0.3 | |
| Kew | " | 23 | day | 11.4 | 10.52 | | | | |
| | | | " | 14.1 | 10.69 | +0.17 | 2.7 | +1.5 | |
| | " | " | night | 23.3 | 10.69 | | | | |
| | | | " | 2.0 | 10.55 | -0.14 | 2.7 | -1.3 | |
| | " | 24 | day | 11.3 | 9.81 | | | | |
| | | | " | 13.8 | 10.12 | +0.31 | 2.5 | +3.1 | |
| | Mean | | | | | | | +0.8 | |
| | Kew | October | 27 | night | h 23.3 | $^{\circ}$ 12.75 | $^{\circ}$ | h | |
| | | | | " | 2.1 | 13.67 | +0.92 | 2.8 | +8.2 |
| | | " | 28 | day | 12.0 | 12.91 | | | |
| | | | " | 14.5 | 13.31 | +0.40 | 2.5 | +4.0 | |
| " | | " | night | 23.6 | 13.13 | | | | |
| | | | " | 2.1 | 13.48 | +0.35 | 2.5 | +3.5 | |
| " | | 29 | day | 12.1 | 12.64 | | | | |
| | | | " | 14.8 | 13.27 | +0.63 | 2.7 | +5.8 | |
| " | | " | night | 23.7 | 13.42 | | | | |
| | | | " | 2.3 | 13.91 | +0.49 | 2.6 | +4.7 | |
| Kew | " | 30 | day | 12.0 | 12.83 | | | | |
| | | | " | 15.5 | 13.31 | +0.48 | 3.5 | +3.4 | |
| | " | " | night | 23.8 | 12.96 | | | | |
| | | | " | 2.2 | 13.26 | +0.30 | 2.4 | +3.1 | |
| | " | 31 | day | 12.1 | 11.25 | | | | |
| | | | " | 14.6 | 11.74 | +0.49 | 2.5 | +4.9 | |
| | Mean | | | | | | | +4.7 | |

Applying the mean corrections for lag found in Table IV to the results given in Table III we obtain the final values of the time of vibration of the mean pendulum at Kew and Greenwich respectively, having 5 values of the former and 2 of the latter.

In Table V these values and their unweighted means are abstracted.

Table V. Times of Vibrations and unweighted means.

Kew.

| Date | Clock | Times from Table III | Lag Correction | Corrected Time of Vibration |
|---------------|----------------|------------------------|----------------|-----------------------------|
| June 22-25 | M. 8702 | ^s 0.5067012 | + 4 | ^s 0.5067016 |
| October 14-16 | M. 8702 | .5066976 | + 4 | .5066980 |
| | Chronr. Mercer | .5066992 | + 4 | .5066996 |
| October 27-31 | M. 8702 | .5066994 | + 5 | .5066999 |
| | S. R. 238 | .5066995 | + 5 | .5067000 |
| MEAN | | | | ^s 0.5066998 |

Greenwich.

| Date | Clock | Times from Table III | Lag Correction | Corrected Time of Vibration |
|---------------|-----------|------------------------|----------------|-----------------------------|
| October 20-24 | S. S. | ^s 0.5067038 | + 1 | ^s 0.5067039 |
| | S. R. 238 | .5067034 | + 1 | .5067035 |
| MEAN | | | | ^s 0.5067037 |

As however the results at Kew are discordant it is desirable to weight the individual values before combining them.

The differences between the individual pendulums and the mean pendulum, which, on the supposition that the pendulums are invariable, should be constant, afford perhaps the best criterion of the relative weights of different sets of observations.

In order to test the invariability of the pendulums the differences from the mean are arranged in chronological order in Table VI; the mean of results obtained on the same date by different clocks has been entered instead of the individual values, as a discrepancy between simultaneous observations cannot be due to an alteration in a pendulum's length.

Table VI. Differences between individual pendulums and the mean pendulum, arranged chronologically.

| Place | Date | 137 | 138 | 139 | 140 |
|-----------|------------|------|--------|-------|--------|
| Kew | June 22-25 | + 71 | + 2497 | - 901 | - 1665 |
| „ | Oct: 14-16 | 63 | 2497 | 898 | 1663 |
| Greenwich | Oct: 20-24 | 69 | 2490 | 895 | 1665 |
| Kew | Oct: 27-31 | 74 | 2483 | 897 | 1661 |

In the case of No. 138 there seems at first sight to be some evidence of progressive change, but on examining Table VII in which all the sets of differences are given, it will be seen that simultaneous observations occasionally disagree by amounts as large as the variation exhibited by No. 138, and it is therefore as probable that the differences are accidental as that they are due to an alteration in the pendulum's length.

Table VII. Differences between individual pendulums and the mean pendulum.

| Station | Determination | 137 | 138 | 139 | 140 |
|-----------|---------------|------|--------|-------|--------|
| Kew | A | + 71 | + 2497 | - 901 | - 1665 |
| " | B | 60 | 2505 | 903 | 1664 |
| " | C | 66 | 2488 | 893 | 1661 |
| " | D | 72 | 2485 | 898 | 1659 |
| " | E | 77 | 2480 | 896 | 1663 |
| Greenwich | A | 69 | 2491 | 891 | 1670 |
| " | B | 68 | 2488 | 898 | 1659 |
| Means | | 69 | 2491 | 897 | 1663 |

Table VIII. Deduction of weights and formation of general means.

| Pendulum | Kew | | | | | | | | | | Greenwich | | | |
|-----------------------------|---------------------------|----|---------------------------|-----|---------------------------|----|---------------------------|----|---------------------------|-----|---------------------------|----|---------------------------|----|
| | A | | B | | C | | D | | E | | A | | B | |
| | v | vv | v | vv | v | vv | v | vv | v | vv | v | vv | v | vv |
| 137 | 2 | 4 | 9 | 81 | 3 | 9 | 3 | 9 | 8 | 64 | 0 | 0 | 1 | 1 |
| 138 | 6 | 36 | 14 | 196 | 3 | 9 | 6 | 36 | 11 | 121 | 0 | 0 | 3 | 9 |
| 139 | 4 | 16 | 6 | 36 | 4 | 16 | 1 | 1 | 1 | 1 | 6 | 36 | 1 | 1 |
| 140 | 2 | 4 | 1 | 1 | 2 | 4 | 4 | 16 | 0 | 0 | 7 | 49 | 4 | 16 |
| [vv] ... | 60 | | 314 | | 38 | | 62 | | 186 | | 85 | | 27 | |
| Weight ... | 5 | | 1 | | 8 | | 5 | | 2 | | 4 | | 12 | |
| Time of Vibration | ^s 0.5067016 | | ^s 0.5066980 | | ^s 0.5066996 | | ^s 0.5067000 | | ^s 0.5066699 | | ^s 0.5067039 | | ^s 0.5067035 | |
| Weighted Means | ^s 0.5067001 | | | | | | | | | | ^s 0.5067036 | | | |
| Difference, Greenwich — Kew | ^s 0.0000035 | | | | | | | | | | | | | |

The Accuracy of the Observations.

The times of vibration of the mean pendulum at Kew and Greenwich respectively, which Behaviour of individual pendulums. are deduced in Table VIII, are the final results of the observations, but it will be of interest to deduce a result from each pendulum separately.

In Table IX the observed times of vibration of each pendulum are combined using the weights deduced in Table VIII, and the differences between the weighted means at Kew and Greenwich are shown. The values of the times of vibration are taken from Tables II & III in which the lag correction has not been applied.

Table IX. Abstract of results by each pendulum and formation of weighted means and their differences.

| Station and Determination | | 137 | | 138 | | 139 | | 140 | |
|---------------------------|------|------------------------|--------|------------------------|--------|------------------------|--------|------------------------|--------|
| | | Time of Vibrn. | Weight | Time of Vibrn. | Weight | Time of Vibrn. | Weight | Time of Vibrn. | Weight |
| KEW | A | ^s 0.5067083 | 5 | ^s 0.5069509 | 5 | ^s 0.5066111 | 5 | ^s 0.5065347 | 5 |
| | B | 036 | 1 | 481 | 1 | 073 | 1 | 312 | 1 |
| | C | 058 | 8 | 480 | 8 | 099 | 8 | 331 | 8 |
| | D | 067 | 5 | 480 | 5 | 097 | 5 | 336 | 5 |
| | E | 071 | 2 | 474 | 2 | 098 | 2 | 331 | 2 |
| | Mean | ^s 0.5067066 | | ^s 0.5069486 | | ^s 0.5066100 | | ^s 0.5065335 | |
| GREENWICH | A | ^s 0.5067107 | 1 | ^s 0.5069529 | 1 | ^s 0.5066147 | 1 | ^s 0.5065368 | 1 |
| | B | 102 | 3 | 522 | 3 | 136 | 3 | 375 | 3 |
| | Mean | ^s 0.5067103 | | ^s 0.5069524 | | ^s 0.5066139 | | ^s 0.5065373 | |
| Difference Lag Correction | | 0.0000037 - 3 | | 0.0000038 - 3 | | 0.0000039 - 3 | | 0.0000038 - 3 | |
| Final Difference | | ^s 0.0000034 | | ^s 0.0000035 | | ^s 0.0000036 | | ^s 0.0000035 | |

An attempt must now be made to estimate the accuracy of the corrected time of vibration of the mean pendulum. For this purpose Table X has been drawn up shewing the result of each double observation of each pendulum, and the sums of the squares of the residuals, thence the probable error of the corrected time of vibration of each pendulum and of the mean pendulum is deduced.

The result of a double observation, that is of one made by night and one by day, with an interval of twelve hours between them, should be, to a great extent, free from the systematic effects of variation in the rate of the clock, and is therefore more suitable for an investigation of accidental errors than the result of a single observation would be.

The figures for the individual pendulums are taken from Table III and those for the mean pendulum from Table II. The lag correction has not been applied.

Table X. Deduction of probable error.

| Station & Determination | Date 1903 | 137 | 138 | 139 | 140 | Mean Pendulum |
|--|---------------------------------------|--|--|--|--|--|
| | | Mean of day and night observations | Mean of day and night observations | Mean of day and night observations | Mean of day and night observations | Mean of day and night observations |
| Kew A | June 22-23 23-24 24-25 | $\begin{smallmatrix} s \\ 0.5067091 \\ 7074 \\ 7083 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069513 \\ 9500 \\ 9514 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066102 \\ 6112 \\ 6118 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065351 \\ 5347 \\ 5343 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5067014 \\ 7008 \\ 7015 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067083 \quad 145$ | $0.5069509 \quad 122$ | $0.5066111 \quad 131$ | $0.5065347 \quad 32$ | $0.5067012 \quad 29$ |
| Kew B | Oct. 14-15 15-16 | $\begin{smallmatrix} s \\ 0.5067024 \\ 7048 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069471 \\ 9490 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066082 \\ 6065 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065315 \\ 5309 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066973 \\ 6978 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067036 \quad 288$ | $0.5069481 \quad 181$ | $0.5066073 \quad 145$ | $0.5065312 \quad 18$ | $0.5066976 \quad 13$ |
| Kew C | Oct. 14-15 15-16 | $\begin{smallmatrix} s \\ 0.5067052 \\ 7064 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069496 \\ 9463 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066100 \\ 6097 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065329 \\ 5334 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066994 \\ 6990 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067058 \quad 72$ | $0.5069480 \quad 545$ | $0.5066099 \quad 5$ | $0.5065331 \quad 13$ | $0.5066992 \quad 8$ |
| Greenwich A | Oct. 20-21 21-22 22-23 23-24 | $\begin{smallmatrix} s \\ 0.5067104 \\ 7110 \\ 7107 \\ 7106 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069527 \\ 9536 \\ 9529 \\ 9522 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066145 \\ 6144 \\ 6151 \\ 6147 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065374 \\ 5383 \\ 5378 \\ 5335 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5067038 \\ 7043 \\ 7041 \\ 7028 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067107 \quad 19$ | $0.5069529 \quad 102$ | $0.5066147 \quad 29$ | $0.5065368 \quad 1450$ | $0.5067038 \quad 134$ |
| Greenwich B | Oct. 20-21 21-22 22-23 23-24 | $\begin{smallmatrix} s \\ 0.5067113 \\ 7102 \\ 7097 \\ 7097 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069523 \\ 9525 \\ 9529 \\ 9511 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066135 \\ 6135 \\ 6139 \\ 6133 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065382 \\ 5372 \\ 5380 \\ 5368 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5067038 \\ 7034 \\ 7036 \\ 7027 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067102 \quad 171$ | $0.5069522 \quad 180$ | $0.5066136 \quad 20$ | $0.5065375 \quad 132$ | $0.5067034 \quad 69$ |
| Kew D | Oct. 27-28 28-29 29-30 30-31 | $\begin{smallmatrix} s \\ 0.5067066 \\ 7059 \\ 7068 \\ 7074 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069474 \\ 9462 \\ 9493 \\ 9491 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066098 \\ 6084 \\ 6111 \\ 6094 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065347 \\ 5324 \\ 5334 \\ 5338 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066996 \\ 6982 \\ 7001 \\ 6999 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067067 \quad 115$ | $0.5069480 \quad 650$ | $0.5066097 \quad 375$ | $0.5065336 \quad 273$ | $0.5066995 \quad 222$ |
| Kew E | Oct. 27-28 28-29 29-30 30-31 | $\begin{smallmatrix} s \\ 0.5067097 \\ 7060 \\ 7066 \\ 7063 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5069477 \\ 9460 \\ 9476 \\ 9483 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5066104 \\ 6091 \\ 6110 \\ 6085 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5065342 \\ 5328 \\ 5323 \\ 5330 \end{smallmatrix}$ | $\begin{smallmatrix} s \\ 0.5067005 \\ 6985 \\ 6994 \\ 6990 \end{smallmatrix}$ |
| | Mean & [vv] | $0.5067071 \quad 886$ | $0.5069474 \quad 290$ | $0.5066098 \quad 398$ | $0.5065331 \quad 195$ | $0.5066994 \quad 218$ |
| $\Sigma[vv]$ | | 1696 | 2070 | 1103 | 2113 | 693 |
| p.e. of mean of day and night observations | | ± 6.9 | ± 7.7 | ± 5.6 | ± 7.8 | ± 4.4 |

$$\text{Probable error} = 0.6745 \sqrt{\frac{\Sigma[vv]}{n-m}}$$

Where n = total number of values
 m = number of groups

Two points are now worthy of attention; the first is that the several values of the time of vibration obtained at Kew differ by considerably more than the probable errors would lead one to expect.

The second point is that the probable error of a result by the mean pendulum is ± 4.4 , whereas if we deduce it from the probable errors of the single pendulums we have

$$\frac{1}{4}\sqrt{(6.9)^2 + (7.7)^2 + (5.6)^2 + (7.8)^2} \\ = \pm 3.6$$

The excess of the value 4.4 over 3.6 is due to the fact that all the pendulums are liable to some influence which remains constant throughout the set, but differs from day to day. It may be safely surmised that errors in the adopted clock rate are the most potent factor in this case.

To investigate the discrepancies between the several Kew results, Table XI has been formed wherein all the observations are treated as one series.

Table XI. Deduction of probable error of time of vibration of mean pendulum at Kew.

| Observed time of vibration | v | vv |
|----------------------------------|-------------|-----|
| Σ | | |
| 0.5067014 | 19 | 361 |
| 0.5067008 | 13 | 169 |
| 0.5067015 | 20 | 400 |
| 0.5066973 | 22 | 484 |
| 0.5066978 | 17 | 289 |
| 0.5066994 | 1 | 1 |
| 0.5066990 | 5 | 25 |
| 0.5066996 | 1 | 1 |
| 0.5066982 | 13 | 169 |
| 0.5067001 | 6 | 36 |
| 0.5066999 | 4 | 16 |
| 0.5067005 | 10 | 100 |
| 0.5066985 | 10 | 100 |
| 0.5066994 | 1 | 1 |
| 0.5066990 | 5 | 25 |
| Σ | | |
| 0.5066995 | [vv] = 2177 | |

$$\text{Probable error of single value} = 0.6745 \sqrt{\frac{2177}{14}} = \pm 8.4$$

$$\text{Probable error of mean} = \pm \frac{8.4}{\sqrt{15}} = \pm 2.2.$$

Here the probable error of a value of the time of vibration of the mean pendulum is ± 8.4 instead of ± 4.4 , and this difference shows that a large proportion of the total error is systematic.

It is difficult to account for the discrepancies between the several results at Kew. If there were discrepancies between the different visits but none between the results of simultaneous observations, one would suspect either the flexure correction or the thermometers, imagining perhaps that the zero errors of the latter were changing; but the comparisons of the thermometers with the standards at Kew, and the severe tests to which the method of determining the flexure has been subjected at Potsdam, give us confidence in the corrections applied, and moreover errors in these corrections would not account for the difference between the two results obtained from simultaneous observations during the second visit to Kew.

The difference between these two values indicates that the clock rate is the source of error, for, whilst the clocks employed were different, all corrections were identical in these two cases. It is true that the rates of the clocks depended on the same star observations, on the same time signals, and on comparisons made by the same observer, so that a systematic error in one of the adopted values can hardly be credited. But there is another point to be considered in this connection.

Any variation in the retardation between the break of circuit in the clock and the action of the flash-lever would have the same effect as a change in the clock rate: thus if we suppose that this retardation amounted to $0^s\cdot01$ during the observation of the first series of coincidences, and to $0^s\cdot015$ during the second series; then, since about 35 minutes separate the two series, we should have an apparent losing rate of $0^s\cdot005$ in 35^m , or of $0^s\cdot2$ per day, which corresponds to a correction of 12×10^{-7} in the time of vibration. In the standard clock, Morrison 8702, electrical contact is made for a very small fraction of each second, and to obtain distinct flashes it was necessary to use great care in adjusting the balance between the spring and the electro-magnet which control the lever of the flash-box. Under these conditions it is conceivable that small changes in the attracting power of the magnet, due to an increase in the residual magnetism of the core, or to polarization of the battery, or to change in the resistance of the coils of the magnet through change of temperature, or to other such cause, may result in the armature being held a little longer or released a little sooner during the second series of observations than during the first.

The difficulty of adjusting the balance alluded to above was greatest when it was necessary, as during the second and third visits, to secure a position in which the flash-lever would respond to either of the two clocks.

The low weights of the results obtained by the Morrison Clock when used in conjunction with another confirm the idea that on these occasions some additional cause of uncertainty was at work.

Reviewing the results of Tables X and XI we may conclude that the probable error of the time of vibration of the mean pendulum, deduced from two sets of observations separated by an interval of 12 hours, will in general be

not less than $\pm 4\cdot4$ nor greater than $\pm 8\cdot4$.

To deduce the probable error of the mean of all the sets of observations at Kew and Greenwich respectively, we may have recourse to Table VIII where the various results and their weights are given.

In Table XII the figures required are repeated.

Table XII. Deduction of probable error at Kew.

| Station | Determination | Time of vibration | Weight p | v | pvv |
|---------------|---------------|--------------------|----------|----|------|
| Kew | A | $^s 0\cdot5067016$ | 5 | 15 | 1125 |
| | B | $\cdot5066980$ | 1 | 21 | 441 |
| | C | $\cdot5066996$ | 8 | 5 | 200 |
| | D | $\cdot5067000$ | 5 | 1 | 5 |
| | E | $\cdot5066999$ | 2 | 2 | 8 |
| Weighted Mean | | $^s 0\cdot5067001$ | 21 | | 1779 |

Probable error of result of unit weight

$$= 0.6745 \sqrt{\frac{1779}{4}} = \pm 14.2$$

Probable error of mean result

$$= \pm \frac{14.2}{\sqrt{21}} = \pm 3.1$$

For Greenwich we may assume that the probable error of a result of unit weight is the same as at Kew, and the sum of the weights being 16 on the same scale we may take the probable error of the mean to be

$$\pm \frac{14.2}{\sqrt{16}} = \pm 3.6.$$

Thus we have finally the following values:—

| | | |
|---|---|------------------------------------|
| Time of vibration of mean pendulum at KEW | = | $0.5067001 \pm 3.1 \times 10^{-7}$ |
| „ at GREENWICH | = | $0.5067036 \pm 3.6 \times 10^{-7}$ |
| difference | = | $0.0000035 \pm 4.5 \times 10^{-7}$ |

The final values of g at Kew and Greenwich.

The value of g at Kew may be assumed to be

$$\overset{cm}{981.200} *$$

Hence, using the formula

$$s^2 g = s_0^2 g_0$$

or more conveniently, for small variations of s ,

$$g = g_0 - 2g_0 \times \frac{s - s_0}{s_0}$$

where s_0 and g_0 are the values of the time of vibration and the acceleration of gravity at the station where both are known, and s and g those at any other station where s alone is known,

we have at Greenwich

$$\begin{aligned} g &= 981.200 - 1962.4 \times \frac{35 \pm 4.5}{.5067001} \times 10^{-7} \\ &= 981.200 - 0.014 \pm 0.002 \\ &= \overset{cm}{981.186} \pm 0.002 \end{aligned}$$

* This value has been adopted by Professor Helmert in his "Bericht über die relativen Messungen der Schwerkraft mit Pendel-apparaten" which appears in the report of the Geodetic Conference of 1900—*vide* page 324. It is based on the preliminary result of the determination of g at Potsdam, viz:— 981.274. Cf. also Appendix No. 5 to the U.S. Coast and Geodetic Survey Report for 1901, page 355.

Theoretical values of g .

It will now be of interest to compare the theoretical values of g with the results of the observations.

In forming these values it is convenient to divide the process into five steps, each producing a correction to the fundamental value of the acceleration due to gravity at a place in latitude 0° , at sea level, far from the neighbourhood of hills or valleys, and where the geological strata have a density equal to the mean surface density of the earth. This fundamental value is taken by Professor Helmert to be 978 centimetres, and his expression for the value at sea level in latitude ϕ is

$$978 (1 + 0.005310 \sin^2 \phi) : \text{this quantity is called } \gamma_0.$$

The corrections to γ_0 are:—

- | | | | | |
|--|-----|-----|-----|---|
| 1. For height above sea level | ... | ... | ... | $-\gamma_0 \frac{2h}{R}$ |
| 2. For the mass between sea level and the station | ... | ... | ... | $+\gamma_0 \frac{3}{4} \cdot \frac{h}{R}$ |
| 3. A geological correction to allow for the actual density of the subjacent rock | ... | ... | ... | $-\gamma_0 \frac{3}{2} \cdot \frac{h'}{R} \cdot \frac{\delta - \theta}{\Delta}$ |
| 4. A correction taking account of the actual conformation of the surrounding country, which in the above expressions has been assumed to be an extensive plain: this is called the orographical correction. It is inappreciable both at Kew and Greenwich. | | | | |

In the above, h = height of station above sea level
 h' = thickness of surface strata of low density
 R = mean radius of the earth = 21,000,000 feet.
 Δ = mean density of the earth = 5.6
 δ = mean surface density = 2.8
 θ = actual density of subjacent strata.

An examination of Mr. Strahan's interesting analysis of the geology of the strata underlying the observatories, reveals that under Kew there are 1140 feet of rock of average specific gravity 2.06—including 150 feet of London Clay—and 97 feet of Limestone, or in all 1237 feet of strata before the Palæozoic floor is reached.

At Greenwich the London Clay and Limestone are absent, and the estimated depth of the Palæozoic floor is 933 feet.

Therefore correction 3 becomes

| | | | | | | |
|---------------|-----|-----|-----|--|---|----------|
| For Kew | ... | ... | ... | $-\gamma_0 \frac{3}{2} \cdot \frac{1140}{21,000,000} \cdot \frac{2.8 - 2.06}{5.6}$ | = | -0.011 |
| For Greenwich | ... | ... | ... | $-\gamma_0 \frac{3}{2} \cdot \frac{933}{21,000,000} \cdot \frac{2.8 - 2.06}{5.6}$ | = | -0.009 |

For convenience the latitudes and heights of the stations of observation are here repeated.

| | Latitude | | | Height |
|-----------|----------|-----|----|---------|
| Kew | 51° | 28' | 6" | 23 feet |
| Greenwich | 51 | 28 | 38 | 155 „ |

Table XIII. Values of the corrections and of the resulting values of g after the application of each.

| Corrections | Kew | | Greenwich | | Difference in g Kew—Greenwich |
|------------------|----------------------|----------------------|----------------------|----------------------|------------------------------------|
| | Amount of correction | Value of g | Amount of correction | Value of g | |
| Latitude ... | <i>cm</i> + 3.178 | <i>cm</i> 981.178 | <i>cm</i> + 3.179 | <i>cm</i> 981.179 | <i>cm</i> — 0.001 |
| Height ... | — 0.002 | .176 | — 0.015 | .164 | + 0.012 |
| Mass ... | + 0.001 | .177 | + 0.006 | .170 | + 0.007 |
| Geological ... | — 0.011 | .166 | — 0.009 | .161 | + 0.005 |
| Orographical ... | 0 | .166 | 0 | .161 | + 0.005 |

Thus the final theoretical values of g are:—

cm
at Kew 981.166
,, Greenwich 981.161

whereas the observed values are:—

at Kew 981.200
,, Greenwich 981.186

The observed values are thus, in both cases, slightly in excess of the calculated values, and the observed difference between them is greater than the calculated difference.

The difference in the values of g at Kew and Greenwich has been determined several times: the various results obtained are here collected.

Table XIV. Difference between g at Kew and g at Greenwich.

| Date | Observers | Method | Kew—Greenwich |
|--------------|--|--|----------------------|
| 1831 1873 | Sabine, Heaviside | By determinations of length of seconds pendulums | <i>cm</i> + 0.069 |
| 1881 | Herschel | Kater's invariable pendulums Nos. 4 and 6 | <i>cm</i> + 0.038 |
| 1888 | Constable, Hollis | Kater's invariable pendulums Nos. 4, 6 and 11 | <i>cm</i> + 0.028 |
| 1900 | Putnam | Three half-seconds pendulums | <i>cm</i> + 0.012 |
| 1903 | Burrard, Constable, Lenox Conyngham | Four half-seconds pendulums | <i>cm</i> + 0.014 |

It is satisfactory to note that the results obtained with the modern form of apparatus agree well with each other and do not greatly differ from the value which theory demands.

This encourages the hope that the many uncertainties which have hitherto surrounded pendulum observations have been to a large extent eliminated, and that henceforward the pendulum may prove as satisfactory in practice as it has always been attractive in theory.

APPENDIX TO CHAPTER I.

On the Geology of the Strata underlying Kew and Greenwich Observatories, and on the specific gravities of the rocks of which the Strata are composed

BY

A. STRAHAN, F.R.S.

Kew Observatory stands on the right bank of the Thames, on a terrace of gravel which averages 21 feet in height above Ordnance Datum.

A well and borehole were sunk close to the same bank of the Thames at a point 160 yards below Richmond Bridge and 33 yards from high-water mark. The well is three quarters of a mile distant from the Observatory in a direction S. 22° E., and its top is 17 feet above Ordnance Datum. The Tertiary strata are nearly horizontal, as is proved by the fact that the top of the Chalk lies at nearly the same level in the well mentioned, in another at the old Richmond water-works, and in a third at the Star and Garter Hotel. The section proved, therefore, is likely to correspond closely with that which underlies the Observatory. The following account is taken from a paper by Professor Judd* and from the *Geology of London* (Memoirs of the Geological Survey) by Mr. W. Whitaker. Prominence however has been given to the lithological characters of the strata in preference to the geological grouping.

Richmond Well and Borehole.

| | | | | | Thickness | Depth |
|---|----------------------|-----|-----|-----|-----------|-------|
| | | | | | feet | feet |
| Made ground | ... | .. | ... | ... | 10 | 10 |
| London Clay | ... | ... | ... | ... | 160 | 170 |
| Reading Beds | { Clay | ... | ... | ... | 44 | 214 |
| | { Sand and Sandstone | ... | ... | ... | 12 | 226 |
| | { Clay | ... | ... | ... | 3½ | 229½ |
| Thanet Sand | ... | ... | ... | ... | 22½ | 252 |
| Chalk with flints | ... | ... | ... | ... | 300 | 552 |
| Chalk with no flints | ... | ... | ... | ... | 150 | 702 |
| Marly Chalk | ... | ... | ... | ... | 220 | 922 |
| Sandstone (Upper Greensand) | ... | ... | ... | ... | 16 | 938 |
| Gault Clay, sandy and conglomeratic at base | ... | ... | ... | ... | 201½ | 1139½ |
| Limestone (Neocomian and Great Oolite Series) | ... | ... | ... | ... | 97½ | 1237 |
| Sandstone and indurated Marl alternating | ... | ... | ... | ... | 117 | 1354 |
| Sandstone | ... | ... | ... | ... | 90½ | 1444½ |

* *Quarterly Journal, Geological Society*, Volume XL, page 724 (1884) and Volume XLI, page 524 (1885).

In the Limestone, at 1203 and 1210 feet depth, water was struck which rose to 46 feet from the surface, and lower down springs were met with a head of water sufficient for a rise of 126 feet above the surface.

The temperature at the bottom was $76\frac{3}{4}^{\circ}$ Fahr., the average increase being 1° for 54.09 feet of descent.

The strata below the depth of 1237 feet were described in the works referred to as being of doubtful age, and were temporarily called "Poikilitic", but an opinion prevailed among those who took part in the discussion that they belonged to the Old Red Sandstone. This view is supported by their character, by the fact that they dip at an angle of about 30° , whereas the Secondary rocks above them are nearly horizontal, and by their corresponding in depth to the position of the Palæozoic floor as proved in other borings in the south-east of England (see Map, Figure 1). The arguments against their being of Old Red Sandstone age are given in full by Professor Judd in the papers alluded to.

The Kew section, as estimated on the data given above, will be found drawn to scale in Figure 2.

Greenwich Observatory is situated at a height of 155 feet above Ordnance Datum on the margin of a tract of Oldhaven Beds. These strata form a gently undulating plateau, rising at a gentle angle northwards. They terminate in that direction in a bold scarp, on a projecting shoulder of which the Observatory stands. In the steep slopes which lie east and north of the building the Woolwich and Reading Beds, the Thanet Sand and the Chalk crop out from beneath the Oldhaven Beds.

A well in the garden of the Observatory is said to have reached the top of the Chalk at 75 feet depth.* The top of the well is about 10 feet below the site of the Observatory, or about 145 feet above Ordnance Datum. The top of the Chalk must therefore lie at a depth of about 85 feet below the Observatory.

The nature of the strata composing these 85 feet can be inferred from other wells in the neighbourhood.

A well at Greenwich Hospital, 770 yards to the north-west of the Observatory yields the following details:—*

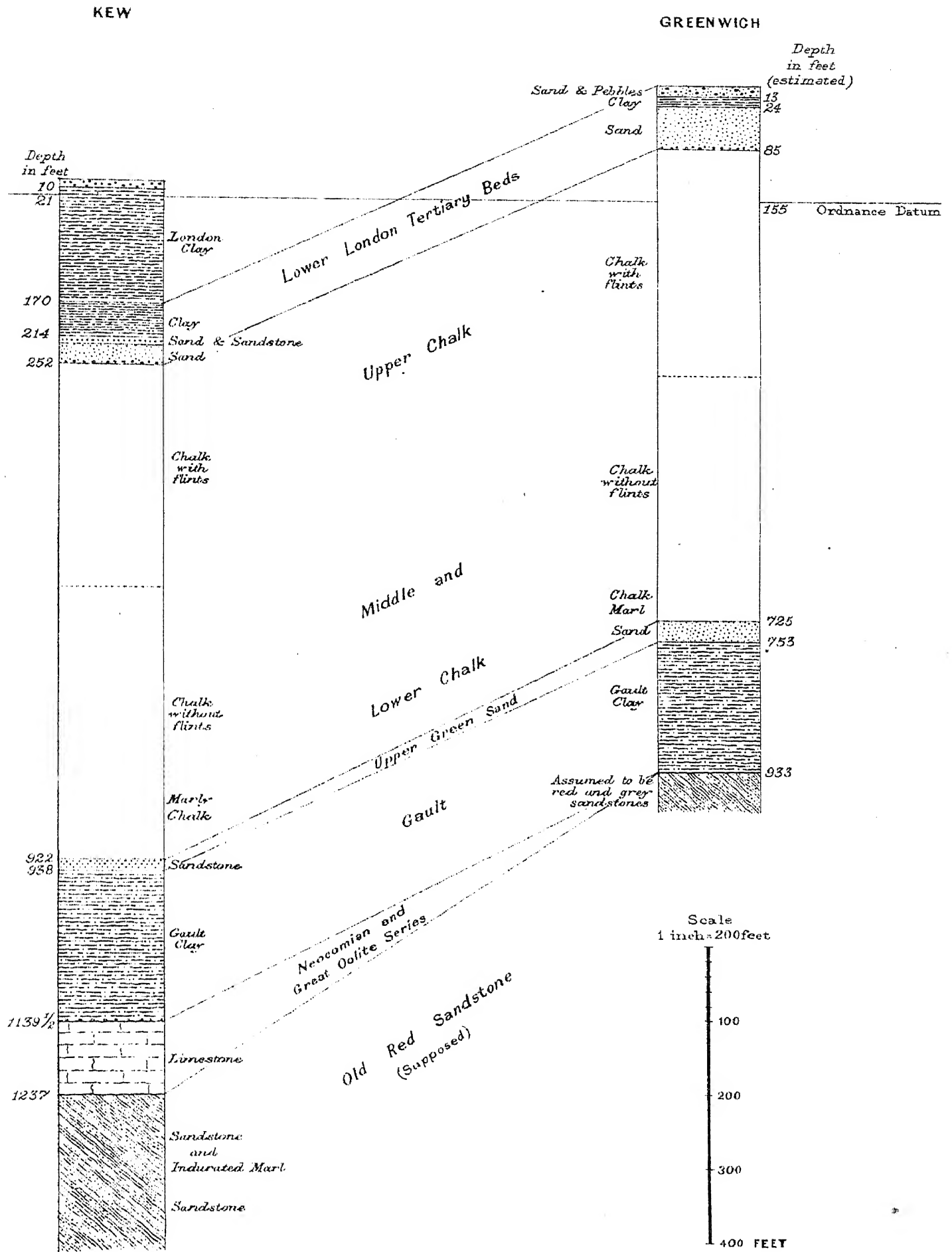
| | | | | | Thickness | | Depth from | |
|--|-------------------------------|-----|-----|-----|-----------|-----|------------|-----|
| | | | | | | | surface | |
| | | | | | ft. | in. | ft. | in. |
| Made ground | ... | ... | ... | ... | 11 | 0 | 11 | 0 |
| Gravel, in part | Blackheath (or Oldhaven) Beds | ... | ... | ... | 33 | 0 | 44 | 0 |
| Woolwich and Reading Beds 25½ feet | Black sand | ... | ... | ... | 4 | 10 | 48 | 10 |
| | Blue clay | ... | ... | ... | | 8 | 49 | 6 |
| | Shelly rock | ... | ... | ... | 4 | 0 | 53 | 6 |
| | Red clay | ... | ... | ... | 6 | 0 | 59 | 6 |
| | White sand (water) | ... | ... | ... | 4 | 0 | 63 | 6 |
| | Green sand and pebbles | ... | ... | ... | 4 | 0 | 67 | 6 |
| Thanet sand (water) | ... | ... | ... | ... | 55 | 10 | 123 | 4 |
| Bed of flints | ... | ... | ... | ... | 1 | 0 | 124 | 4 |

The strata vary in detail, but the occurrence of pebble-beds in the Oldhaven and Woolwich Beds, and of bands of clay in the latter is a fairly constant feature. In default of more precise information the lower 85 feet of this section may be taken to represent the strata which rest upon the Chalk under the Observatory.

The thickness of the Chalk must be estimated from more distant sources.

* *Geology of London*, Volume II, page 73.

Fig. 2



At Mile End a well was sunk for the Albion Brewery at 172 Whitechapel Road.* It reached the top of the Chalk at a depth of 201 feet, and its bottom at 855 feet, proving its thickness to be 654 feet. The Chalk contained flints and layers of flint in the upper 259 feet. The remainder was hard and flintless, becoming marly towards the bottom. This well is situated $3\frac{3}{8}$ miles from the Observatory in a direction N. 39° W.

A well at Meux Brewery† at the junction of Tottenham Court Road and New Oxford Street is situated $6\frac{1}{4}$ miles from the Observatory in a direction W. 26° N. Here the top of the Chalk was reached at a depth of $157\frac{1}{2}$ feet and the bottom at 812 feet, giving a total thickness of $654\frac{1}{2}$ feet. Flints occurred in the upper 347 feet, and for 32 feet upwards from its base the Chalk was described as a chalk marl or a light-blue clay.

A well near Streatham Common Station‡ is situated $7\frac{1}{4}$ miles from the Observatory in a direction W. 36° S. The top of the Chalk was reached at a depth of $241\frac{1}{2}$ feet and its bottom at $864\frac{1}{2}$ feet, indicating a thickness of 623 feet. The upper 220 feet are described as containing flints and being very hard, and the lower 20 or 30 feet as being marly and clayey.

A well at Crossness§, situated $7\frac{3}{4}$ miles from the Observatory in a direction E. 3° N., proved the top of the Chalk at a depth of $143\frac{1}{2}$ feet and the bottom at 802 feet, giving a thickness of $658\frac{1}{2}$ feet. Flints were more or less plentiful in the upper 447 feet and the lower 32 feet were grey marl.

On comparing these data we find that the thickness of the Chalk under the Observatory, as judged by the Crossness and Mile End wells, is likely to be between 654 and 658 feet, but that the Streatham Common Well indicates a southerly attenuation. As the Observatory lies south of a line drawn from Crossness to Mile End, this attenuation must be taken into account, and the thickness under the Observatory may be estimated at 640 feet. The Upper Greensand lies next below the Chalk. In one of the borings at Crossness its thickness is given as 65 feet, but there is no doubt that this includes some chalk marl, as suggested by Prestwich.|| At Mile End it was penetrated to a depth of 20 feet, and at Meux Brewery and at Streatham it was proved to be 28 and $28\frac{1}{2}$ feet thick respectively. It may be assumed to be 28 feet thick under the Observatory.

The Gault was 175 feet thick at Crossness, 160 feet at Meux Brewery and $188\frac{1}{2}$ feet at Streatham Common. It is likely to be 180 feet thick under the Observatory.

Below the Gault there may be some Jurassic strata. At Meux Brewery 64 feet of limestone belonging to the Great Oolite Series were penetrated, and at Streatham Common $38\frac{1}{2}$ feet of limestone and clay believed to belong to the Forest Marble. It has already been noted that there were $97\frac{1}{2}$ feet of limestone below the Gault at Richmond, part of which however were thought to be of Neocomian age. On the other hand at Crossness the Gault has been proved to lie directly upon Palæozoic rocks||. These facts indicate a westward thickening of the Jurassic strata. They come in again eastwards of Crossness also as proved at Chatham but whether they exist under Greenwich is doubtful. On the whole it will probably be safer to assume their absence.

The depth at which the Palæozoic rocks are likely to occur beneath Greenwich Observatory remains to be considered. At Crossness rocks described as rock-shale and very hard grey quartzose sandstones were reached at 1002 feet below Ordnance Datum. They were assigned by Prestwich to the Old Red Sandstone or Devonian, but were thought by Mr. Whitaker to be more probably Triassic¶. At Meux Brewery red and green shales with thin quartzites, all assigned to the Upper Devonian, were reached at 979 feet below Ordnance Datum. At Streatham Common red, grey and greenish sandstones were reached at 1010 feet below that datum. At Richmond alternations of sandstone and indurated marl were reached at 1220 feet below that datum. The red and greenish sandstones reached at Streatham were left by Mr. Whitaker as "of doubtful age", but they correspond in character to parts of the Old Red Sandstone of South Wales. This

* J. Barrow. *Proc. S. Wales Inst. Eng.* Volume XI, page 326 and *Geology of London*, Volume II page 135 (1889). This and the other deep wells referred to are shown in Figure I.

† Prestwich and Moore, *Quarterly Journal Geological Society*, Volume XXIV, page 902 and *Geology of London* Volume II, page 165, (1889).

‡ *Geology of London*, Volume II, page 224. (1889).

§ *Geology of London*, Volume II, page 66. This is not the deep boring referred to later on.

|| *Quarterly Journal, Geological Society*, Volume XXXIV, page 913 (1878).

¶ *Geology of London*, Volume II, page 68.

similarity taken in connection with the fact that they dipped at about 30° and occurred at about the depth at which the Palæozoic floor might be expected, seems to justify their being assigned to the Old Red Sandstone. For the same reasons the red rocks proved at Richmond are more probably of Devonian than of Triassic age.

If the Palæozoic floor were a plane its depth under Greenwich could be calculated precisely from these data, but it is known to undulate, though it rises on the whole with a remarkably even and gentle gradient towards the north or north-east under London. Judged by the Meux and Streatham sections it would be about 990 feet below Ordnance Datum, but on adding up the thicknesses assigned above to the Tertiary and Secondary strata we get a depth of only 930 feet. The latter is probably the more reliable estimate, and the complete sequence of the strata underlying Greenwich Observatory will therefore be as follows (see also Figure 2) :—

| | | | | | | Thickness | Depth |
|---|------|--|-----|-----|-----|-----------|-------|
| | | | | | | feet | feet |
| Lower London | { | Sand and pebbles | ... | ... | ... | 13 | 13 |
| Tertiary Beds | { | Blue and red clay | ... | ... | ... | 11 | 24 |
| 85 feet | { | Sand, with a layer of flints at the bottom | ... | ... | ... | 61 | 85 |
| Chalk 640 feet | { | Chalk with flints | ... | ... | ... | 310 | 395 |
| | { | Chalk without flints | ... | ... | ... | 300 | 695 |
| | { | Chalk marl | ... | ... | ... | 30 | 725 |
| Upper Greensand | Sand | ... | ... | ... | ... | 28 | 753 |
| Gault | Clay | ... | ... | ... | ... | 180 | 933 |
| Palæozoic Rocks, assumed to be red, grey and greenish sandstone as at Streatham Common. | | | | | | | |

The Observatory being 155 feet above Ordnance Datum the Palæozoic floor will be only 778 feet below that datum. The highest points in that floor yet proved in the London district are Kentish Town, Turnford and Ware, where it lay 939, 870½ and 686½ feet respectively below Ordnance Datum. Its calculated height under Greenwich was therefore somewhat unexpected.

Its height is accounted for by an anticline and fault which trend in a direction E. 30° N. on the north-west side of the Observatory. The existence of the anticline is proved by the depths at which the top of the Chalk has been reached in various borings. Near Blackheath the Chalk was touched at about Ordnance Datum, but in the Observatory well at 70 feet above that datum, the rise therefore being 70 feet in about half a mile, or about 1 in 38, towards the north-west. Again at the Hospital the top of the Chalk lies 98 feet below Ordnance Datum and at the Atlas Works in West Ferry Road,* on the opposite side of the river, at 84 feet below the datum, proving that the rise north-westwards continues thus far, as shewn in Figure 3. But a little further north its depth increases to 100 and 200 feet below the datum.

The fault is believed to run about 300 yards north-west of the Observatory. It is referred to by Mr. Whitaker as the most important fault (or system of faulting) in the London Basin. It was seen in two railway-cuttings south of Deptford†, and is fixed approximately in position by a well in East Street, Greenwich, where the top of the Chalk lies 134 feet below Ordnance Datum, and 204 feet below its level under the Observatory. Beyond this it is believed by Mr. Whitaker to curve southwards by Woolwich and to merge into the slight roll that affects the junction of the Tertiary Beds and the Chalk on the north side of the Thames near Purfleet and Stifford. The throw of the fault at Greenwich must be 204 feet plus an allowance for the dip, or about 230 feet in all.

There can be no doubt therefore that the Palæozoic floor has been raised locally under Greenwich by post-Tertiary earth-movements, though that there was pre-Cretaceous elevation also of part of the district is proved by the fact that the Gault rests directly upon that floor at Crossness. The following table gives the depths at which the floor has been reached in various parts of the south-east of England.

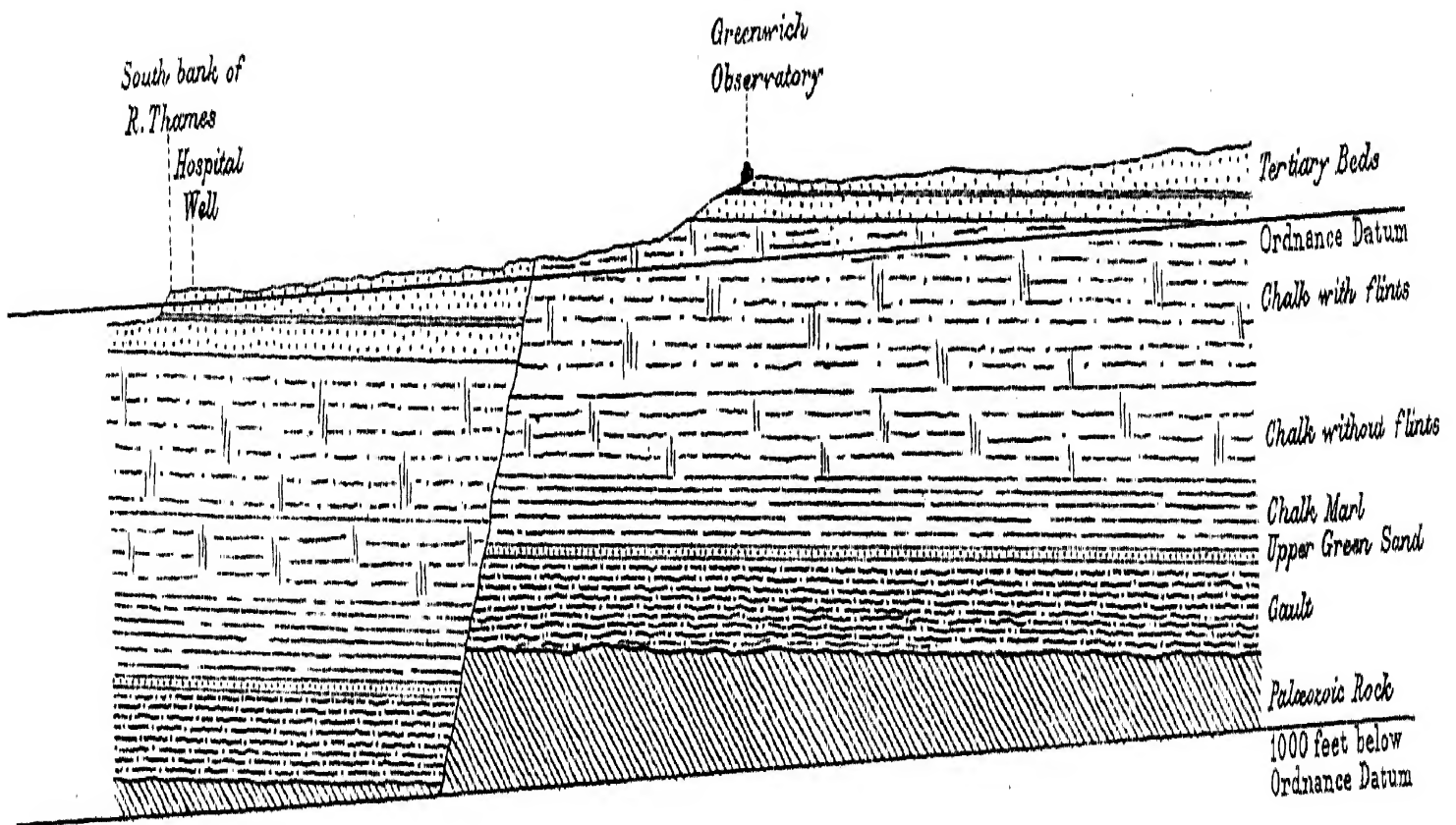
* *Some Middlesex Well-sections. Trans. Brit. Assoc. Water-works Eng., Volume II. 1897.*

† *Geology of London, Volume I. page 485. 1889.*

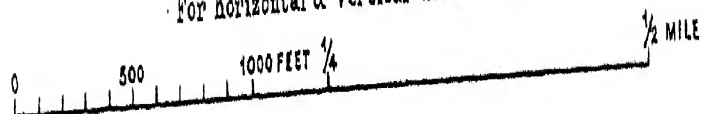
Fig.3

S.32°E.

N.32°W.



SCALE
6 Inches = 1 Mile
For horizontal & vertical distances



Depths to the Palæozoic floor in the east and south of England. (See Figure 1.)

| | | | Depth from surface feet | | | Depth below Ordnance Datum. feet |
|-------------------|-----|-----|----------------------------|-----|-----|-------------------------------------|
| Harwich | ... | ... | 1025½ | ... | ... | 1015 |
| Stutton | ... | ... | 994 | ... | ... | 974 |
| Weeley | ... | ... | 1094½ | ... | ... | 1040* |
| Ware | ... | ... | 796½ | ... | ... | 686½ |
| Turnford | ... | ... | 980½ | ... | ... | 870½ |
| Loughton | ... | ... | (not reached at 1096) | ... | ... | ... |
| Kentish Town | ... | ... | 1113 | ... | ... | 939 |
| Meux Brewery | ... | ... | 1064 | ... | ... | 978½ |
| Streatham | ... | ... | 1120 | ... | ... | 1010 |
| Richmond | ... | ... | 1237 | ... | ... | 1220 |
| Crossness | ... | ... | 1008 | ... | ... | 1001½ |
| Brabourne | ... | ... | 1905 | ... | ... | ... |
| Ropersole | ... | ... | 1581 | ... | ... | 1181 |
| Ellinge | ... | ... | 1686 | ... | ... | 1280 (about) |
| Dover No. 2 Shaft | ... | ... | 1157 | ... | ... | 1103 |

To the west of London a boring at Winkfield near Windsor failed to reach Palæozoic rocks at 1243 feet (1025 feet below Ordnance Datum).

To the south-west a boring at Brookwood ended in Chalk at 884 feet; others at Southampton, Portsmouth and Goodwood left off in Chalk at 1313, 1037 and 1012 feet respectively.

To the south and south-east a boring at Penshurst was in Kimeridge Clay at 1864 feet and one at Warren Farm, the Industrial School east of Brighton, was in Lower Greensand at 1285 feet. The Sub-Wealden boring at Battle left off in Oxford Clay at 1905 feet.

To the east-south-east the Pluckley boring was abandoned in Kimeridge Clay at 1698 feet, but the Brabourne boring reached Palæozoic rocks at 1905 feet. Further east the Ropersole and Ellinge borings have reached Coal Measures at depths of 1581 and 1686 feet (1181 and 1280 feet below Ordnance Datum) respectively, while the Dover Shaft, No. 2, has entered them at a depth of 1157 feet or 1103 below Ordnance Datum.

At Calais the Palæozoic floor was reached at 1102 feet.

To the east of London a boring at Chatham ended in Oxford Clay at 965 feet and another at Sheerness ended in Chalk at 805 feet.

From these data it is possible to contour parts of the Palæozoic floor. For example a contour-line drawn at 1000 feet below Ordnance Datum runs between Ware and Winkfield, and must trend generally north-westwards between Northampton and Rugby. In the opposite direction it passes between Kentish Town and Richmond, runs close to Streatham and through Crossness, but keeps clear of Chatham where one boring ended in Lower Greensand at 1035 feet, while another ended in Oxford Clay at 947 feet below Ordnance Datum, probably not far above the Palæozoic rocks. The Dover Shaft, No. 2, entered the Coal Measures at 1103 feet below Ordnance Datum, nor have the older rocks been found to the south-east of Crossness within 1000 feet of Ordnance Datum. The contour-line must therefore double back to the north-west passing between Loughton and the other neighbouring borings. Thence its position is hypothetical as far as Harwich, where it is determined by the Harwich, Weeley and Stutton borings. Further north it probably passes near Coombs, where a boring ended in Gault at 895 feet, and certainly keeps to the east of Culford where a boring reached Palæozoic rocks at 637 feet (527 feet below Ordnance Datum).

Nothing is known of the Palæozoic rocks of the broad tract between Culford, Harwich Crossness and Ware. The Loughton boring, which failed to reach them at 1096 feet, shews that it would not be safe to assume that they lie within 1000 feet of Ordnance Datum over the whole of the tract, but for the purposes of the present enquiry this is immaterial.

* I have been unable to ascertain the height of the site of the boring above Ordnance Datum. This figure is calculated on the assumption that the height is between 50 and 60 feet.

As regards the structure of the Palæozoic floor it is known only that Silurian rocks were reached at Ware and Devonian at Meux Brewery, in Tottenham Court Road. Old Red Sandstone was recognised at Crossness, and occurred probably at Kentish Town, Richmond and Streatham also. The relative positions of these rocks suggest a southerly dip, and some experiments at Turnford and Ware indicated a dip of 25° in a direction S. 25° W. and a dip of 41° in a direction S. 1° W., at the two places respectively*. At Richmond and elsewhere the dip was about 30° ; but at Bra-bourne much higher, a fact which suggests that the nearly horizontal Coal Measures proved at Dover and Ropersole are terminated westwards by a fault, not improbably the continuation of one of the great lines of disturbance proved in the Pas de Calais Coal Field.

It will be seen therefore that there is a gentle eminence in the Palæozoic floor, running in a north-west, or west-north-west direction under London, and extending, but with diminished height, towards Dover in the opposite direction. Towards the south-west the slope as reckoned between Ware and Richmond falls at the rate of about 1 in 257, but the floor undulates and between Kentish Town and Richmond the gradient amounts to about 1 in 141. Kew Observatory stands over this steeper part of the slope. Under Greenwich the floor appears to be gently arched up and faulted as described, the Observatory being situated on the southern side of the crest of the arch.

The principal differences therefore between the stratigraphical columns beneath the two Observatories may be summed up as follows:—

Under Kew Observatory there are 150 feet of London Clay near the surface and $97\frac{1}{2}$ feet of Limestone at a depth, both of which are absent at Greenwich.

Under Kew the Palæozoic floor lies at a depth of 1237 feet below the surface as compared with 933 feet at Greenwich.

Lastly Greenwich Observatory stands on the southern limb of a gentle post-Tertiary anticline.

Specific Gravities.

The following specimens were collected for the purpose of ascertaining the specific gravities of the various rocks underlying Kew and Greenwich:—

1. London Clay from a depth of 60 to 70 feet under St. George's Circus, Blackfriars Road.
2. Do. do. 60 feet under Hyde Park Corner.
3. Do. do. 36 feet under Jermyn Street.
4. Woolwich and Reading Beds (Clay); Crondall Pottery, Surrey.
5. Thanet Sand; Charlton.
6. Upper Chalk; Charlton.
7. Flint; Charlton.
8. Chalk Marl from a depth of 450 feet; Chatham Waterworks.
9. Upper Greensand from a depth of 823 feet; Richmond Boring.
10. Upper Greensand; Merstham.
11. Gault from a depth of 990 feet; Meux Brewery, Tottenham Court Road.
12. Great Oolite (limestone) from a depth of 1001 to 1065 feet; Richmond Boring.
13. Old Red Sandstone from a depth of 1411 feet; Richmond Boring.
14. Do. (marl) 1180 feet; Streatham Boring.
15. Do. do. 1204 feet; do

The determinations were made in the laboratory at Jermyn Street by Dr. W. Pollard, from whose report I have drawn up the following account:—

The specimens were roughly crushed so as to pass through a sieve of 8 holes to the inch. Moisture given off at 105° C. was determined. The specific gravity of the samples before drying was determined in pycnometers, and that of the dried rock calculated.

To ascertain the amount of water the dried specimens were capable of absorbing, glass tubes open at one end, and with a piece of linen tied over the other, were used. The weight of the tubes after moistening the linen and allowing to drain thoroughly was determined. The tubes

* J. Francis: *Report, Brit. Assoc.* 1895, page 441.

were then filled with the respective specimens, weighed, and placed in distilled water for 24 hours, so as to allow the water to soak upwards into them. When they were thoroughly soaked any excess of water was allowed to drain off in an atmosphere saturated with moisture. They were then weighed at weekly intervals. After seven weeks some had become constant, but others continued to lose moisture after 10 weeks, when the experiment was discontinued. The results obtained are shewn in the following table:—

| No. of specimens | Specific gravities as calculated for the dried rock | | | | | | 1 part of water by weight retained in parts of each specimen | | | | Days after commencement of experiment | | |
|------------------|---|-----|-----|------|-----|-----|--|-------|--------|-----|---|-----|-----------|
| 1 | ... | ... | ... | 2.76 | ... | ... | 1.77* | and | 1.66* | ... | ... | ... | 49 |
| 2 | ... | ... | ... | 2.76 | ... | ... | 1.75* | ... | 1.69 | ... | ... | ... | 49 |
| 3 | ... | ... | ... | 2.77 | ... | ... | 2.05 | ... | 2.01* | ... | ... | ... | 49 |
| 4 | ... | ... | ... | 2.88 | ... | ... | 2.32 | ... | 2.40 | ... | ... | ... | 77 |
| 5 | ... | ... | ... | 2.66 | ... | ... | 4.37 | ... | 4.42 | ... | ... | ... | 76 |
| 6 | ... | ... | ... | 2.72 | ... | ... | 2.99 | ... | 3.08 | ... | ... | ... | 76 |
| 7 | ... | ... | ... | 2.60 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 8 | ... | ... | ... | 2.77 | ... | ... | 2.84 | ... | 3.02 | ... | ... | ... | 76 |
| 9 | ... | ... | ... | 2.73 | ... | ... | 4.10 | ... | 4.34* | ... | ... | ... | 75 |
| 10 | ... | ... | ... | 2.54 | ... | ... | 2.52 | ... | 2.83* | ... | ... | ... | 75 |
| 11 | ... | ... | ... | 2.76 | ... | ... | 2.19 | ... | 2.34 | ... | ... | ... | 73 |
| 12 | ... | ... | ... | 2.73 | ... | ... | 10.95* | ... | 10.82* | ... | ... | ... | 63 and 73 |
| 13 | ... | ... | ... | 2.65 | ... | ... | 144 | ... | 166 | ... | ... | ... | ... |
| 14 | ... | ... | ... | 2.74 | ... | ... | ... | 24.76 | ... | ... | ... | ... | ... |
| 15 | ... | ... | ... | 2.76 | ... | ... | ... | 128 | ... | ... | ... | ... | ... |

Dr. Pollard further notes, as sources of error, that the tubes were not packed under the conditions of pressure &c., which obtain at a depth, and that changes of temperature in the laboratory probably account for some irregularities observed in the draining off of the water.

No. 7 (Flint) was considered to be non-absorbent. The specific gravities of Nos. 13, 14 and 15 (Old Red Sandstone and Marl) were determined by suspending them in water allowing them to drain for a few hours in a moist atmosphere, then weighing, drying at 105° C. and weighing again.

It being evident that no confidence could be placed in the determination of the water-capacity of some of the specimens, it was decided to make further experiments on specimens in as nearly as possible the condition as to moisture in which they occurred in nature. For this purpose the following rocks were freshly dug, enclosed at once in tin boxes and brought to the laboratory:—

1. London Clay from a depth of 60 feet; Dover Street, Piccadilly.
2. Upper Chalk; Strood, Kent.
3. Middle Chalk; Blue Bell Hill Upper Pit, Burham, Kent.
4. Lower Chalk; Merstham, Surrey.
5. Chalk Marl; Blue Bell Hill Lower Pit, Burham, Kent.
6. Gault; Burham Brick Pit, Kent.

The specific gravity of each specimen in the condition in which it reached the laboratory was determined in various oils. The result was satisfactory for the Clays, but not for the Chalks from which the air could not be removed. In every case a determination was made also by pyknometer.

* This weighing varied by 0.1 gram or less from the previous weighing and is regarded as practically constant.

| No. of specimen | Sp. Gr. in oil | Sp. Gr. in water | Percentage of water by weight | Sp. Gr. of dried specimen in pyknometer | Sp. Gr. calculated from that of the moist specimen |
|-----------------|----------------|------------------|-------------------------------|---|--|
| 1 | 2.054* | 2.050 | 19.66 | 2.746 | 2.760 |
| 2 | 2.026 | 2.072 | 18.33 | 2.673 | 2.729 |
| 3 | 2.395† | 2.405 | 7.29 | 2.694 | 2.701 |
| 4 | 2.048 | 2.062 | 18.27 | 2.702 | 2.703 |
| 5 | 2.096‡ | 2.108 | 16.54 | 2.700 | 2.701 |
| 6 | 1.995 | 1.995 | 21.12 | 2.718 | 2.719 |

It will be seen that the specific gravities of all the specimens except the Clays are lower as determined in oil than in water, which points to the air not having been entirely eliminated.

The calculated specific gravity is also in every case slightly higher than that directly determined on the dried sample in the pyknometer. This is probably due to the dried powder having absorbed moisture on the balance.

With respect to specimen 3 the moisture percentage is probably much too low and the other results unreliable. This may be due to the specimen having lost water in the quarry, though it was got in as nearly a natural condition as possible. Two lumps were therefore suspended and boiled in water for two or three hours, and when cold weighed in water. They were then allowed to drain for 15 minutes, weighed, drained for another 15 minutes, reweighed and finally dried at 105° C. From these data the specific gravity was found to be

| | |
|-------------|-----------------|
| Wet Samples | 2.016 and 2.072 |
| Dry Samples | 2.511 and 2.558 |

Water percentage (by weight) in wet sample 16.14 and 15.04.

The specific gravities thus determined are 0.190 and 0.143 respectively lower than the calculated specific gravity. The difference is probably due to incomplete drying and to some air being still contained. The percentage of water, however, is probably nearer that which exists in the Chalk under the Observatories than the percentage given in the table.

In summing up these results, we must bear in mind that there are several discrepancies which point to the advisability of further experiments, and that an absolutely true result could be obtained only by experimenting on the rocks in the conditions of moisture and pressure in which they occur in nature. The results, so far as the experiments have gone, are embodied in the following table:—

| | Specific gravity in natural condition | Percentage of water by weight |
|------------------------|---------------------------------------|-------------------------------|
| London Clay | 2.050 | 19.66 |
| Upper Chalk | 2.072 | 18.33 |
| § Chalk-flint | 2.600 | ... |
| Lower Chalk | 2.062 | 18.27 |
| Chalk Marl | 2.108 | 16.54 |
| Gault | 1.995 | 21.12 |
| Great Oolite limestone | 2.383 | 8.42 |
| Old Red Sandstone | 2.622 | 0.65 |
| Do. (marl) | 2.567 | 3.88 |
| Do. | 2.723 | 0.77 |

* A specimen dried at 105° C. gave a specific gravity of 2.739 in the oil.

† After being in vacuo all night: all the figures relating to No. 3 in the table are probably unreliable.

‡ After being in vacuo for 48 hours.

§ Flint-layers may be estimated to constitute about 1½ per cent of the Upper Chalk.

|| The figures calculated from the table on page 37.

CHAPTER II.

The Observations in 1904.

[January to June].

On the arrival of the pendulum apparatus in India in January 1904 a set of observations was made in Dehra Dún in the same room as had been used by Captain Basevi in 1870 and 1871. The primary object of these observations was to determine the difference between the value of g at Dehra Dún and its value at Kew. A secondary object was to establish a connection between the new series of observations and those made between 1865 and 1870 by Captains Basevi and Heaviside. In order to strengthen this connection it was decided that during the first tour four more of Basevi's stations should be visited, namely Calcutta, Madras, Bombay and Mussooree, and that the circuit should be completed by a second visit to Dehra Dún.

The building in which Basevi observed in Mussooree has changed hands, and though permission to observe there on this occasion was obtained, it seemed unlikely that it would be again available, and a second station in Mussooree was therefore selected in case of its proving desirable at any future time to make another set of observations which should be comparable with those of the present series.

Dehra Dun.

| | | | | | |
|-----------------------------|-----|-----|-----------|-----|-----|
| Latitude | ... | ... | 30° | 19' | 29" |
| Longitude | ... | ... | 78 | 3 | 15 |
| Height above mean sea level | ... | ... | 2239 feet | | |

The apparatus was set up in the room known as the Transit room. It was in this room that Basevi observed and the new pendulum station is almost identical with the old one.

A small pedestal of brick in cement was built to receive the pendulum stand. Its dimensions were 2 feet 3 inches square at bottom, 1 foot 6 inches square at top, and 1 foot 8 inches high.

Similar pedestals were built at all the stations visited during this season. The granite slab was cemented to this pedestal, and the pendulum stand was screwed tightly to the slab.

The clock S.R. 238, was set up on an iron tripod stand which had been made in Dehra Dún. The tripod has three levelling screws which can be firmly clamped.

The time observations were made with Transit Instrument No. 2. by Messrs. Troughton and Simms, which belongs to the Longitude equipment purchased in 1894. The transits were recorded on one of the chronographs of the same equipment. In January and February 1904, break-circuit chronometer Bond No. 480 was used for the star transits and the rate of S. R. 238 was deduced by means of comparisons made on the chronograph.

All the star observations in January and February were made by Lieut. H. M. Cowie, R. E. The programme contained from 8 to 12 zenithal stars, and 2 or 3 polar stars for the determination of the deviation in azimuth. The same stars were observed each night.

The thermometers were the same as those used at Kew and Greenwich.

The temperature conditions were not very good. The room is large and lofty but the roof is of iron and in the day time there was an appreciable rise of temperature. A lag correction has consequently been applied both here and at all the stations of this season, employing the same formula as had been used at Kew and Greenwich.

The flexure correction was determined seven times. On the first three occasions I forgot to place the screen between the driving and the driven pendulums; when I discovered its omission I made further observations with and without the screen so as to ascertain what difference the absence of the screen would make in the correction. It was found that with the screen in position the correction was greater by 4.3×10^{-7} than when the driven pendulum was unprotected from the air set in motion by the driving pendulum. This result was to be expected, for the driven pendulum follows a quarter of an oscillation behind the other, so that the air set in motion has a retarding effect on its movement.

The results of the flexure observations are shewn in the following table:—

| Date 1904 | Flexure Correction | |
|--------------------|-----------------------|------------------------|
| | Without Screen | With Screen |
| January 20 | 28.3×10^{-7} | 32.6×10^{-7} |
| " 21 | 29.7 | 34.0 |
| " 29 | 30.4 | 34.7 |
| February 8 | ... | 35.3 |
| " 8 | ... | 34.4 |
| " 9 | ... | 35.2 |
| " 9 | ... | 35.8 |
| Mean | ... | 34.57×10^{-7} |
| Adopted Correction | ... | $- 35 \times 10^{-7}$ |

Calcutta.

The room in which Captain Basevi observed was no longer available, but the Rector of St. Xavier's College kindly placed the lower storey of the observatory in the college grounds at my disposal. The observatory is less than 100 yards from Basevi's station.

The observations began at night and passed without incident, but next day when I began to observe I found that the arc of vibration kept changing and that the time of oscillation was quite irregular.

The cause of the irregularity was unquestionably earth-tremors set up by the traffic. The whole city of Calcutta may almost be said to be floating and the movement of vehicles sets up waves in the flexible crust.

The following is the record of one of several series of observations of the amplitude of the vibration of a pendulum, caused by these waves, the pendulum having been completely brought to rest at the beginning of the observation.

| Time | | Arc of vibration | | Time | | Arc of vibration | |
|------|----|------------------|---|------|----|------------------|----|
| m | s | ' | " | m | s | ' | " |
| 20 | 20 | ... | 0 | 27 | 40 | ... | 0 |
| | 40 | ... | 4 | 30 | 15 | ... | 5 |
| 21 | 25 | ... | 0 | 31 | 50 | ... | 9 |
| | 50 | ... | 2 | 32 | 45 | ... | 12 |
| 23 | 0 | ... | 0 | 34 | 30 | ... | 14 |
| | 30 | ... | 2 | 38 | 0 | ... | 17 |
| 24 | 30 | ... | 3 | 39 | 40 | ... | 11 |
| 26 | 30 | ... | 4 | 41 | 35 | ... | 7 |

The irregularity in the time of vibration was well shewn by the fact that the estimated time of the 61st coincidence, which in general is not in error by more than 1^s or $1^s.5$, was here apt to be wrong by fully 10 seconds.

Different times of the day, and planes of oscillation in different azimuths were tried, but without producing any improvement. It was clear that it was impossible to obtain a trustworthy result in this part of Calcutta, and the observations were abandoned.

When Basevi observed here 24 years ago it is probable that the vibrations of the ground were much less marked than they are now, for there has been a great increase in the volume of the traffic in the interval; furthermore it is very likely that the long pendulums used by him were less sensitive to these tremors on account of their greater period.

I am surprised however that I have come across no mention of this difficulty in connection with the Austrian pendulum observations. It appears* that two separate sets of observations were made, the one in 1893 and the other in 1897, and both in the very same place as that which I occupied, and with precisely similar pendulums. Yet though allusion is made to ground vibrations in other places (*e. g.* Port Said & Yokohama) nothing is said of any trouble in Calcutta.

Madras.

| | | | | | |
|-----------------------------|-----|-----|--------------|----|------|
| Latitude | ... | ... | 13° | 4' | 8" |
| Longitude | ... | ... | 80 | 14 | 54 |
| Height above mean sea level | ... | ... | ... | 20 | feet |

The room in the observatory which had been occupied by Basevi was available, and was kindly placed at my disposal by Professor R. Ll. Jones, the Director. The arrangements were the same as in Dehra Dún, except that the time determinations were undertaken by Mr. Solomon, the First Assistant in the observatory, with the large transit instrument. The sidereal clock belonging to the observatory is not provided with electrical contacts and I therefore made the comparison between it and S. R. 238 by means of a mean time chronometer which was lent me for the purpose.

The temperature conditions were satisfactory. The flexure was determined six times with the following results:—

| Date | | Flexure Correction |
|--------------------|-----|-----------------------|
| March 3 | ... | 38.6×10^{-7} |
| " " | ... | 41.7 |
| " 6 | ... | 37.8 |
| " " | ... | 38.4 |
| " 8 | ... | 38.4 |
| " " | ... | 37.0 |
| Mean | ... | 38.7×10^{-7} |
| Adopted Correction | ... | $- 39 \times 10^{-7}$ |

Colaba.

| | | | | | |
|-----------------------------|-----|-----|--------------|-----|------|
| Latitude | ... | ... | 18° | 53' | 45" |
| Longitude | ... | ... | 72 | 48 | 47 |
| Height above mean sea level | ... | ... | ... | 34 | feet |

The out-building of the observatory which was lent to Captain Heaviside in 1873 was kindly placed at my disposal by Mr. Moos, the Superintendent. The position of this building is not very well suited to pendulum observations as it lies very near the public road and the floor is consequently somewhat liable to surface vibrations.

* *Comptes-rendus de la Treizième Conférence Générale de l' Association Géodésique Internationale*, 1900. p. 184.

It is possible that there is some mistake about the place in which the observations of 1897 were made, for the authorities at St. Xavier's College, though they knew all about the observations of 1893, had no recollection of any in 1897.

The rate of the clock was determined by transits which I observed myself with Transit Instrument No. 2. by Troughton and Simms. The programme included 12 zenithal and 4 polar stars. The clock's rate was rather unsteady, this may have been due to vibrations of the floor.

The temperature conditions were fairly satisfactory.

The flexure correction was determined six times with the following results:—

| Date | | Flexure Correction | |
|--------------------|----|--------------------|-----------------------|
| March | 16 | ... | 39.5×10^{-7} |
| " | " | ... | 39.4 |
| " | 20 | ... | 36.1 |
| " | " | ... | 38.9 |
| " | 23 | ... | 38.2 |
| " | " | ... | 38.5 |
| Mean | | ... | 38.4×10^{-7} |
| Adopted Correction | | ... | -38×10^{-7} |

Mussooree (*Dunseverick*).

Latitude ... 30° 27' 28"
 Longitude ... 78 3 33
 Height above mean sea level ... 7129 feet

The apparatus was erected in a room in the lower storey of the house called *Dunseverick*. This house is situated on the eastern end of a ridge which runs nearly due east and west; the ground falls very steeply on three sides, but on the fourth it continues at about the same level, though with irregular ups and downs, for about 7 miles and then descends gradually to the Jumna.

There is a bench-mark of the G. T. Survey in the verandah just outside the pendulum room, so that the height above sea level is known with an unusual degree of accuracy for a station in the hills. The temperature conditions were good.

I made the time determinations myself, using Transit Instrument No. 2 by T. & S.

The flexure correction was determined six times with the following results:—

| Date | | Flexure Correction | |
|--------------------|----|--------------------|-----------------------|
| April | 21 | ... | 41.5×10^{-7} |
| " | " | ... | 41.0 |
| " | 25 | ... | 40.5 |
| " | " | ... | 39.1 |
| " | 27 | ... | 40.9 |
| " | " | ... | 41.7 |
| Mean | | ... | 40.8×10^{-7} |
| Adopted Correction | | ... | -41×10^{-7} |

Mussooree (*Camel's Back*).

Latitude $30^{\circ} 27' 35''$
 Longitude $78 \quad 4 \quad 32$
 Height above mean sea level 6924 feet

This was Basevi's station. The house which he built expressly for the pendulums, and which was close to the house formerly used as the G. T. Office, had when I reached Mussooree been almost entirely pulled down, with a view to the erection of a larger one. The owner however gave me permission to use a part of the new house as soon as the roof was on, and before the inside fittings were commenced. The roof was of iron, so to improve the temperature conditions I had a temporary thatch laid on the top of it.

The exact site of Basevi's pillar was not discoverable, but the new station is certainly not as much as 10 feet from the old one.

The height above M. S. L. was obtained by levelling from a bench-mark of the G. T. Survey which was only a few yards away.

I made the time determinations myself.

The flexure correction was determined four times with the following results:—

| Date | | Flexure Correction |
|--------------------|-----|-----------------------|
| May 12 | ... | 38.7×10^{-7} |
| " " | ... | 37.5 |
| " 20 | ... | 36.0 |
| " " | ... | 35.3 |
| Mean | ... | 36.9×10^{-7} |
| Adopted Correction | ... | $- 37 \times 10^{-7}$ |

Dehra Dun.

Latitude $30^{\circ} 19' 29''$
 Longitude $78 \quad 3 \quad 15$
 Height above mean sea level 2239 feet

The closing observations in Dehra Dún were made in the same room as were those at the beginning of the tour. Two series of observations were made; during the first the break-circuit chronometer Bond 480 was used both for stars and pendulums, and the transits were observed partly by me and partly by Sub-assistant Superintendent Hanuman Prasad.

During the second series the clock S. R. 238 was used and all the star observations were made by Babu Hanuman Prasad.

The temperature conditions were not very satisfactory.

The flexure correction was determined five times as follows:—

| Date | | Flexure Correction |
|--------------------|-----|-----------------------|
| May 26 | ... | 29.7×10^{-7} |
| " 27 | ... | 29.5 |
| " 30 | ... | 30.3 |
| " " | ... | 27.8 |
| June 5 | ... | 28.4 |
| Mean | ... | 29.1×10^{-7} |
| Adopted Correction | ... | $- 29 \times 10^{-7}$ |

Table I. Details of the Observations.

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|---------|---------------------------|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| Dehra Dun—(Basevi's Station). | | | | | | | | | | | | | | | | |
| 25-26 January, 1904. | | | | | | | | | | | | | | | | |
| 137 | 5 21 | 34.413 | -1.88 | 16 | 13.31 | -0.01 | 0.881 | 0.5073717 | +110 | -7 | -652 | 0 | -523 | -35 | 0.5072610 | |
| 139 | 6 14 | 34.863 | 1.88 | 14 | 13.34 | 0.01 | 0.881 | 0.5072753 | 110 | 5 | 654 | 0 | 534 | 35 | 0.5071635 | |
| 138 | 7 8 | 33.347 | 1.88 | 15 | 13.32 | 0.01 | 0.881 | 0.5076111 | 110 | 6 | 653 | 0 | 504 | 35 | 0.5075023 | |
| 140 | 7 59 | 35.224 | 1.88 | 14 | 13.29 | 0.01 | 0.881 | 0.5071997 | 110 | 5 | 651 | 0 | 534 | 35 | 0.5070882 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072538 | |
| 137 | 17 24 | 34.463 | -1.88 | 15 | 11.82 | +0.57 | 0.883 | 0.5073610 | +110 | -6 | -579 | +14 | -525 | -35 | 0.5072589 | |
| 139 | 18 15 | 34.900 | 1.88 | 15 | 12.25 | 0.57 | 0.882 | 0.5072675 | 110 | 6 | 600 | 14 | 534 | 35 | 0.5071624 | |
| 138 | 19 9 | 33.374 | 1.88 | 14 | 12.82 | 0.57 | 0.878 | 0.5076048 | 110 | 5 | 628 | 14 | 502 | 35 | 0.5075002 | |
| 140 | 20 3 | 35.243 | 1.88 | 16 | 13.30 | 0.57 | 0.875 | 0.5071958 | 110 | 7 | 652 | 14 | 530 | 35 | 0.5070858 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072518 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072528 | |
| 26-27 January, 1904. | | | | | | | | | | | | | | | | |
| 140 | 5 35 | 35.215 | -1.73 | 16 | 13.55 | -0.01 | 0.877 | 0.5072016 | +102 | -7 | -664 | 0 | -531 | -35 | 0.5070881 | |
| 138 | 6 29 | 33.333 | 1.73 | 15 | 13.68 | 0.01 | 0.876 | 0.5076143 | 102 | 6 | 670 | 0 | 501 | 35 | 0.5075033 | |
| 139 | 7 23 | 34.847 | 1.73 | 14 | 13.61 | 0.01 | 0.876 | 0.5072788 | 102 | 5 | 667 | 0 | 531 | 35 | 0.5071652 | |
| 137 | 8 17 | 34.401 | 1.73 | 14 | 13.61 | 0.01 | 0.876 | 0.5073743 | 102 | 5 | 667 | 0 | 520 | 35 | 0.5072618 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072546 | |
| 140 | 17 35 | 35.270 | -1.73 | 16 | 12.05 | +0.49 | 0.878 | 0.5071902 | +102 | -7 | -590 | +12 | -532 | -35 | 0.5070852 | |
| 138 | 18 33 | 33.379 | 1.73 | 15 | 12.50 | 0.49 | 0.876 | 0.5076036 | 102 | 6 | 613 | 12 | 501 | 35 | 0.5074095 | |
| 139 | 19 26 | 34.885 | 1.73 | 14 | 12.93 | 0.49 | 0.873 | 0.5072706 | 102 | 5 | 634 | 12 | 529 | 35 | 0.5071617 | |
| 137 | 20 22 | 34.425 | 1.73 | 14 | 13.38 | 0.49 | 0.869 | 0.5073692 | 102 | 5 | 656 | 12 | 516 | 35 | 0.5072594 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072515 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072530 | |
| 29-30 January, 1904. | | | | | | | | | | | | | | | | |
| 139 | 5 56 | 34.850 | -1.66 | 15 | 13.64 | -0.06 | 0.879 | 0.5072780 | +97 | -6 | -668 | -2 | -533 | -35 | 0.5071633 | |
| 137 | 6 51 | 34.399 | 1.66 | 15 | 13.66 | 0.06 | 0.877 | 0.5073748 | 97 | 6 | 669 | 2 | 521 | 35 | 0.5072612 | |
| 140 | 7 48 | 35.217 | 1.66 | 15 | 13.56 | 0.06 | 0.880 | 0.5072011 | 97 | 6 | 664 | 2 | 533 | 35 | 0.5070868 | |
| 138 | 8 45 | 33.338 | 1.66 | 15 | 13.50 | 0.06 | 0.878 | 0.5076131 | 97 | 6 | 662 | 2 | 502 | 35 | 0.5075021 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072534 | |
| 139 | 17 47 | 34.899 | -1.66 | 12 | 12.39 | +0.52 | 0.880 | 0.5072678 | +97 | -4 | -607 | +13 | -533 | -35 | 0.5071609 | |
| 137 | 18 48 | 35.586 | 1.66 | 14 | 12.84 | 0.52 | 0.878 | 0.5073663 | 97 | 5 | 629 | 13 | 522 | 35 | 0.5072582 | |
| 140 | 19 48 | 35.235 | 1.66 | 15 | 13.38 | 0.52 | 0.874 | 0.5071972 | 97 | 6 | 656 | 13 | 530 | 35 | 0.5070855 | |
| 138 | 20 47 | 33.340 | 1.66 | 15 | 13.94 | 0.52 | 0.871 | 0.5076126 | 97 | 6 | 683 | 13 | 498 | 35 | 0.5075014 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072515 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072525 | |
| 3-4 February, 1904. | | | | | | | | | | | | | | | | |
| 138 | 6 10 | 33.367 | -2.50 | 15 | 13.37 | +0.06 | 0.879 | 0.5076065 | +147 | -6 | -655 | +1 | -503 | -35 | 0.5075014 | |
| 140 | 7 3 | 35.249 | 2.50 | 14 | 13.44 | 0.06 | 0.878 | 0.5071946 | 147 | 5 | 659 | 1 | 532 | 35 | 0.5070863 | |
| 137 | 8 0 | 34.439 | 2.50 | 15 | 13.51 | 0.06 | 0.878 | 0.5073661 | 147 | 6 | 662 | 1 | 522 | 35 | 0.5072584 | |
| 139 | 8 55 | 34.883 | 2.50 | 16 | 13.53 | 0.06 | 0.878 | 0.5072710 | 147 | 7 | 663 | 1 | 532 | 35 | 0.5071621 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072521 | |
| 137 | 18 20 | 34.450 | -2.50 | 14 | 13.01 | +0.49 | 0.879 | 0.5073638 | +147 | -5 | -637 | +12 | -522 | -35 | 0.5072598 | |
| 139 | 19 13 | 34.893 | 2.50 | 16 | 13.44 | 0.49 | 0.876 | 0.5072691 | 147 | 7 | 659 | 12 | 531 | 35 | 0.5071618 | |
| 138 | 20 9 | 33.361 | 2.50 | 16 | 13.95 | 0.49 | 0.872 | 0.5076079 | 147 | 7 | 684 | 12 | 499 | 35 | 0.5075013 | |
| 140 | 21 4 | 35.231 | 2.50 | 15 | 14.36 | 0.49 | 0.871 | 0.5071983 | 147 | 6 | 704 | 12 | 528 | 35 | 0.5070869 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072525 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072523 | |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|---------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 4-5 February, 1904. | | | | | | | | | | | | | | | | |
| 137 | 6 21 | 34' 42.1 | -2.45 | 15 | 13° 70 | -0.05 | 0.877 | 0.5073700 | +144 | -6 | -671 | -1 | -521 | -35 | 0.5072610 | |
| 139 | 7 18 | 34' 86.9 | 2.45 | 15 | 13° 73 | 0.05 | 0.876 | 0.5072740 | 144 | 6 | 673 | 1 | 531 | 35 | 0.5071638 | |
| 138 | 8 17 | 33' 35.0 | 2.45 | 16 | 13° 66 | 0.05 | 0.877 | 0.5076102 | 144 | 7 | 669 | 1 | 502 | 35 | 0.5075032 | |
| 140 | 9 12 | 35' 23.5 | 2.45 | 15 | 13° 58 | 0.05 | 0.877 | 0.5071973 | 144 | 6 | 665 | 1 | 531 | 35 | 0.5070879 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072540 |
| 140 | 18 25 | 35' 26.9 | -2.45 | 15 | 12° 81 | +0.52 | 0.877 | 0.5071905 | +144 | -6 | -628 | +13 | -531 | -35 | 0.5070862 | |
| 138 | 19 23 | 33' 37.5 | 2.45 | 15 | 13° 26 | 0.52 | 0.876 | 0.5076046 | 144 | 6 | 650 | 13 | 501 | 35 | 0.5075011 | |
| 139 | 20 23 | 34' 88.6 | 2.45 | 14 | 13° 83 | 0.52 | 0.872 | 0.5072705 | 144 | 5 | 678 | 13 | 528 | 35 | 0.5071616 | |
| 137 | 21 48 | 34' 41.6 | 2.45 | 15 | 14° 52 | 0.52 | 0.868 | 0.5073711 | 144 | 6 | 711 | 13 | 516 | 35 | 0.5072600 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072522 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072531 |
| 5-6 February, 1904. | | | | | | | | | | | | | | | | |
| 140 | 6 23 | 35' 22.1 | -2.48 | 14 | 13° 97 | -0.04 | 0.878 | 0.5072003 | +146 | -5 | -685 | -1 | -532 | -35 | 0.5070891 | |
| 138 | 7 27 | 33' 34.5 | 2.48 | 16 | 14° 03 | 0.04 | 0.878 | 0.5076115 | 146 | 7 | 687 | 1 | 502 | 35 | 0.5075029 | |
| 139 | 8 21 | 34' 86.8 | 2.48 | 15 | 13° 96 | 0.04 | 0.878 | 0.5072743 | 146 | 6 | 684 | 1 | 532 | 35 | 0.5071631 | |
| 137 | 9 14 | 34' 42.0 | 2.48 | 14 | 13° 88 | 0.04 | 0.879 | 0.5073702 | 146 | 5 | 680 | 1 | 522 | 35 | 0.5072605 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072539 |
| 138 | 18 16 | 33' 38.5 | -2.48 | 14 | 12° 94 | +0.51 | 0.879 | 0.5076022 | +146 | -5 | -634 | +13 | -503 | -35 | 0.5075004 | |
| 140 | 19 10 | 35' 25.7 | 2.48 | 15 | 13° 39 | 0.51 | 0.875 | 0.5071928 | 146 | 6 | 656 | 13 | 530 | 35 | 0.5070860 | |
| 137 | 20 9 | 34' 43.6 | 2.48 | 16 | 13° 85 | 0.51 | 0.873 | 0.5073668 | 146 | 7 | 679 | 13 | 519 | 35 | 0.5072587 | |
| 139 | 21 4 | 34' 87.5 | 2.48 | 15 | 14° 31 | 0.51 | 0.872 | 0.5072729 | 146 | 6 | 701 | 13 | 528 | 35 | 0.5071618 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072517 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072528 |
| Madras. | | | | | | | | | | | | | | | | |
| 3-4 March, 1904. | | | | | | | | | | | | | | | | |
| 137 | 10 24 | 33' 11.1 | +3.39 | 15 | 26° 79 | +0.01 | 0.900 | 0.5076662 | -199 | -6 | -1313 | 0 | -535 | -39 | 0.5074570 | |
| 139 | 11 15 | 33' 51.1 | 3.39 | 16 | 26° 87 | 0.01 | 0.900 | 0.5075733 | 199 | 7 | 1317 | 0 | 545 | 39 | 0.5073626 | |
| 138 | 12 9 | 32' 10.0 | 3.39 | 16 | 26° 84 | 0.01 | 0.900 | 0.5079113 | 199 | 7 | 1315 | 0 | 515 | 39 | 0.5077038 | |
| 140 | 13 1 | 33' 83.7 | 3.39 | 15 | 26° 86 | 0.01 | 0.901 | 0.5074993 | 199 | 6 | 1316 | 0 | 546 | 39 | 0.5072887 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5074530 |
| 137 | 22 29 | 33' 10.6 | +3.39 | 14 | 26° 39 | +0.14 | 0.900 | 0.5076673 | -199 | -5 | -1293 | +4 | -535 | -39 | 0.5074606 | |
| 139 | 23 22 | 33' 50.6 | 3.39 | 15 | 26° 57 | 0.14 | 0.901 | 0.5075746 | 199 | 6 | 1302 | 4 | 546 | 39 | 0.5073658 | |
| 138 | 0 21 | 32' 09.1 | 3.39 | 16 | 26° 71 | 0.14 | 0.898 | 0.5079136 | 199 | 7 | 1309 | 4 | 514 | 39 | 0.5077072 | |
| 140 | 1 19 | 33' 82.8 | 3.39 | 14 | 26° 80 | 0.14 | 0.897 | 0.5075013 | 199 | 5 | 1313 | 4 | 544 | 39 | 0.5072917 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5074563 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5074547 |
| 4-5 March, 1904. | | | | | | | | | | | | | | | | |
| 137 | 10 28 | 33' 09.0 | +3.30 | 14 | 26° 43 | -0.04 | 0.901 | 0.5076710 | -194 | -5 | -1295 | -1 | -535 | -39 | 0.5074641 | |
| 139 | 11 22 | 33' 50.4 | 3.30 | 15 | 26° 46 | 0.04 | 0.903 | 0.5075749 | 194 | 6 | 1297 | 1 | 547 | 39 | 0.5073665 | |
| 138 | 12 17 | 32' 10.3 | 3.30 | 17 | 26° 40 | 0.04 | 0.903 | 0.5079106 | 194 | 8 | 1294 | 1 | 517 | 39 | 0.5077053 | |
| 140 | 13 7 | 33' 84.0 | 3.30 | 15 | 26° 33 | 0.04 | 0.902 | 0.5074987 | 194 | 6 | 1290 | 1 | 547 | 39 | 0.5072910 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5074567 |
| 137 | 22 34 | 33' 10.7 | +3.30 | 14 | 25° 76 | +0.24 | 0.902 | 0.5076672 | -194 | -5 | -1262 | +6 | -536 | -39 | 0.5074642 | |
| 139 | 23 26 | 33' 52.5 | 3.30 | 16 | 26° 06 | 0.24 | 0.901 | 0.5075701 | 194 | 7 | 1277 | 6 | 546 | 39 | 0.5073644 | |
| 138 | 0 19 | 32' 11.7 | 3.30 | 17 | 26° 25 | 0.24 | 0.898 | 0.5079071 | 194 | 8 | 1286 | 6 | 514 | 39 | 0.5077036 | |
| 140 | 1 13 | 33' 84.5 | 3.30 | 15 | 26° 42 | 0.24 | 0.898 | 0.5074973 | 194 | 6 | 1295 | 6 | 544 | 39 | 0.5072901 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5074556 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5074562 |

Table I. Details of the Observations—(Continued).

[illegible]

Table I. Details of the observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|--------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|---------|--|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 20-21 March, 1904. | | | | | | | | | | | | | | | | |
| 139 | 10 4 | 33.993 | +0.56 | 16 | 25.85 | -0.11 | 0.903 | 0.5074643 | -33 | -7 | -1267 | -3 | -547 | -38 | 0.5072748 | |
| 137 | 11 5 | 33.571 | 0.56 | 15 | 25.75 | 0.11 | 0.903 | 0.5075596 | 33 | 6 | 1262 | 3 | 536 | 38 | 0.5073718 | |
| 140 | 12 8 | 34.344 | 0.56 | 15 | 25.62 | 0.11 | 0.903 | 0.5073870 | 33 | 6 | 1255 | 3 | 547 | 38 | 0.5071988 | |
| 138 | 13 4 | 32.556 | 0.56 | 16 | 25.56 | 0.11 | 0.902 | 0.5077988 | 33 | 7 | 1252 | 3 | 516 | 38 | 0.5076139 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073648 | |
| 139 | 22 21 | 34.025 | +0.56 | 16 | 25.35 | +0.51 | 0.902 | 0.5074571 | -33 | -7 | -1242 | +13 | -547 | -38 | 0.5072717 | |
| 137 | 23 29 | 33.595 | 0.56 | 14 | 25.67 | 0.51 | 0.901 | 0.5075542 | 33 | 5 | 1258 | 13 | 535 | 38 | 0.5073686 | |
| 140 | 0 26 | 34.352 | 0.56 | 17 | 26.20 | 0.51 | 0.895 | 0.5073852 | 33 | 8 | 1284 | 13 | 542 | 38 | 0.5071960 | |
| 138 | 1 21 | 32.541 | 0.56 | 15 | 26.61 | 0.51 | 0.895 | 0.5078026 | 33 | 6 | 1304 | 13 | 512 | 38 | 0.5076146 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073627 | |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum ... 0.5073638 | |
| 21-22 March, 1904. | | | | | | | | | | | | | | | | |
| 138 | 10 6 | 32.544 | +0.80 | 15 | 25.94 | -0.08 | 0.902 | 0.5078018 | -47 | -6 | -1271 | -2 | -516 | -38 | 0.5076138 | |
| 140 | 10 58 | 34.334 | 0.80 | 15 | 25.91 | 0.08 | 0.900 | 0.5073891 | 47 | 6 | 1270 | 2 | 545 | 38 | 0.5071983 | |
| 137 | 11 57 | 33.564 | 0.80 | 15 | 25.83 | 0.08 | 0.900 | 0.5075611 | 47 | 6 | 1266 | 2 | 535 | 38 | 0.5073717 | |
| 139 | 12 52 | 33.996 | 0.80 | 17 | 25.73 | 0.08 | 0.902 | 0.5074637 | 47 | 8 | 1261 | 2 | 547 | 38 | 0.5072734 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073643 | |
| 138 | 22 19 | 32.561 | +0.80 | 15 | 25.23 | +0.37 | 0.904 | 0.5077977 | -47 | -6 | -1236 | +9 | -517 | -38 | 0.5076142 | |
| 140 | 23 13 | 34.348 | 0.80 | 14 | 25.58 | 0.37 | 0.903 | 0.5073860 | 47 | 6 | 1253 | 9 | 547 | 38 | 0.5071978 | |
| 137 | 0 10 | 33.578 | 0.80 | 16 | 25.94 | 0.37 | 0.900 | 0.5075596 | 47 | 7 | 1271 | 9 | 535 | 38 | 0.5073707 | |
| 139 | 1 6 | 33.995 | 0.80 | 16 | 26.27 | 0.37 | 0.897 | 0.5074637 | 47 | 7 | 1287 | 9 | 544 | 38 | 0.5072723 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073638 | |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum ... 0.5073641 | |
| Mussooree (Dunseverick). | | | | | | | | | | | | | | | | |
| 22-23 April, 1904. | | | | | | | | | | | | | | | | |
| 137 | 12 1 | 33.789 | +8.50 | 16 | 16.19 | +0.13 | 0.722 | 0.5075100 | -499 | -7 | -793 | +3 | -429 | -41 | 0.5073334 | |
| 139 | 12 57 | 34.217 | 8.50 | 17 | 16.41 | 0.13 | 0.721 | 0.5074146 | 499 | 8 | 804 | 3 | 437 | 41 | 0.5072360 | |
| 138 | 13 55 | 32.743 | 8.50 | 16 | 16.52 | 0.13 | 0.721 | 0.5077537 | 499 | 7 | 809 | 3 | 412 | 41 | 0.5075772 | |
| 140 | 14 51 | 34.553 | 8.50 | 16 | 16.56 | 0.13 | 0.721 | 0.5073413 | 499 | 7 | 811 | 3 | 437 | 41 | 0.5071621 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073272 | |
| 137 | 0 1 | 33.798 | +8.50 | 18 | 16.12 | +0.11 | 0.722 | 0.5075079 | -499 | -9 | -790 | +3 | -429 | -41 | 0.5073314 | |
| 139 | 0 57 | 34.228 | 8.50 | 17 | 16.33 | 0.11 | 0.721 | 0.5074122 | 499 | 7 | 800 | 3 | 437 | 41 | 0.5072341 | |
| 138 | 1 51 | 32.754 | 8.50 | 17 | 16.40 | 0.11 | 0.721 | 0.5077510 | 499 | 8 | 804 | 3 | 412 | 41 | 0.5075749 | |
| 140 | 2 47 | 34.569 | 8.50 | 17 | 16.47 | 0.11 | 0.720 | 0.5073380 | 499 | 8 | 807 | 3 | 436 | 41 | 0.5071592 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073249 | |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum ... 0.5073261 | |
| 23-24 April, 1904. | | | | | | | | | | | | | | | | |
| 140 | 12 1 | 34.562 | +8.17 | 17 | 16.61 | +0.14 | 0.719 | 0.5073397 | -480 | -8 | -814 | +3 | -436 | -41 | 0.5071621 | |
| 138 | 12 58 | 32.740 | 8.17 | 17 | 16.87 | 0.14 | 0.719 | 0.5077542 | 480 | 8 | 827 | 3 | 411 | 41 | 0.5075778 | |
| 139 | 13 55 | 34.204 | 8.17 | 16 | 16.94 | 0.14 | 0.718 | 0.5074176 | 480 | 7 | 830 | 3 | 435 | 41 | 0.5072386 | |
| 137 | 14 52 | 33.769 | 8.17 | 17 | 17.08 | 0.14 | 0.718 | 0.5075146 | 480 | 8 | 837 | 3 | 426 | 41 | 0.5073357 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073286 | |
| 140 | 0 20 | 34.570 | +8.17 | 18 | 16.64 | +0.08 | 0.721 | 0.5073378 | -480 | -9 | -815 | +2 | -437 | -41 | 0.5071598 | |
| 138 | 1 13 | 32.751 | 8.17 | 17 | 16.77 | 0.08 | 0.720 | 0.5077517 | 480 | 8 | 822 | 2 | 412 | 41 | 0.5075756 | |
| 139 | 2 6 | 34.223 | 8.17 | 18 | 16.82 | 0.08 | 0.720 | 0.5074133 | 480 | 9 | 824 | 2 | 436 | 41 | 0.5072345 | |
| 137 | 3 2 | 33.786 | 8.17 | 17 | 16.90 | 0.08 | 0.720 | 0.5075106 | 480 | 8 | 828 | 2 | 428 | 41 | 0.5073323 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073255 | |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum ... 0.5073271 | |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|-------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 18-19 May, 1904. | | | | | | | | | | | | | | | | |
| 137 | 13 54 | 33.907 | +7.10 | 15 | 14.16 | +0.13 | 0.731 | 0.5074835 | -417 | -6 | -694 | + | 3 | -434 | -37 | 0.5073250 |
| 139 | 14 54 | 34.317 | 7.10 | 15 | 14.44 | 0.13 | 0.732 | 0.5073927 | 417 | 6 | 708 | | 3 | 444 | 37 | 0.5072318 |
| 138 | 15 54 | 32.842 | 7.10 | 17 | 14.48 | 0.13 | 0.731 | 0.5077300 | 417 | 8 | 710 | | 3 | 418 | 37 | 0.5075713 |
| 140 | 16 51 | 34.661 | 7.10 | 14 | 14.60 | 0.13 | 0.731 | 0.5073183 | 417 | 5 | 715 | | 3 | 443 | 37 | 0.5071569 |
| | | | | | | | | | | | | | | Mean | ... | 0.5073213 |
| 137 | 2 15 | 33.894 | +7.10 | 14 | 14.21 | +0.18 | 0.731 | 0.5074862 | -417 | -5 | -696 | + | 5 | -434 | -37 | 0.5073278 |
| 139 | 3 15 | 34.319 | 7.10 | 16 | 14.42 | 0.18 | 0.730 | 0.5073923 | 417 | 7 | 707 | | 5 | 442 | 37 | 0.5072318 |
| 138 | 4 12 | 32.841 | 7.10 | 18 | 14.59 | 0.18 | 0.730 | 0.5077301 | 417 | 9 | 715 | | 5 | 418 | 37 | 0.5075710 |
| 140 | 5 7 | 34.664 | 7.10 | 15 | 14.72 | 0.18 | 0.730 | 0.5073177 | 417 | 6 | 721 | | 5 | 442 | 37 | 0.5071559 |
| | | | | | | | | | | | | | | Mean | ... | 0.5073216 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5073214 |
| Dehra Dun—(Basevi's Station). | | | | | | | | | | | | | | | | |
| 27-28 May, 1904. | | | | | | | | | | | | | | | | |
| 137 | 14 37 | 34.130 | -2.34 | 14 | 28.18 | -0.11 | 0.822 | 0.5074338 | +137 | -5 | -1381 | - | 3 | -488 | -29 | 0.5072569 |
| 139 | 15 34 | 34.575 | 2.34 | 14 | 28.14 | 0.11 | 0.822 | 0.5073367 | 137 | 5 | 1379 | | 3 | 498 | 29 | 0.5071590 |
| 138 | 16 33 | 33.075 | 2.34 | 14 | 28.02 | 0.11 | 0.823 | 0.5076746 | 137 | 5 | 1373 | | 3 | 471 | 29 | 0.5075002 |
| 140 | 17 35 | 34.923 | 2.34 | 15 | 27.86 | 0.11 | 0.823 | 0.5072626 | 137 | 6 | 1365 | | 3 | 499 | 29 | 0.5070861 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072506 |
| 137 | 2 45 | 34.124 | -2.34 | 13 | 28.10 | +0.42 | 0.819 | 0.5074352 | +137 | -5 | -1377 | + | 11 | -486 | -29 | 0.5072603 |
| 139 | 3 41 | 34.563 | 2.34 | 15 | 28.57 | 0.42 | 0.817 | 0.5073393 | 137 | 6 | 1400 | | 11 | 495 | 29 | 0.5071611 |
| 138 | 4 40 | 33.066 | 2.34 | 13 | 28.96 | 0.42 | 0.814 | 0.5076768 | 137 | 5 | 1419 | | 11 | 466 | 29 | 0.5074997 |
| 140 | 5 35 | 34.905 | 2.34 | 15 | 29.31 | 0.42 | 0.813 | 0.5072663 | 137 | 6 | 1436 | | 11 | 493 | 29 | 0.5070847 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072514 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072510 |
| 28-29 May, 1904. | | | | | | | | | | | | | | | | |
| 140 | 14 36 | 34.907 | -2.34 | 16 | 28.57 | -0.24 | 0.822 | 0.5072658 | +137 | -7 | -1400 | - | 6 | -498 | -29 | 0.5070855 |
| 138 | 15 37 | 33.055 | 2.34 | 12 | 28.41 | 0.24 | 0.824 | 0.5076795 | 137 | 4 | 1392 | | 6 | 471 | 29 | 0.5075030 |
| 139 | 16 38 | 34.550 | 2.34 | 17 | 28.16 | 0.24 | 0.822 | 0.5073421 | 137 | 8 | 1380 | | 6 | 498 | 29 | 0.5071637 |
| 137 | 17 33 | 34.104 | 2.34 | 15 | 27.90 | 0.24 | 0.824 | 0.5074397 | 137 | 6 | 1367 | | 6 | 489 | 29 | 0.5072637 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072540 |
| 140 | 2 53 | 34.914 | -2.34 | 15 | 28.46 | +0.33 | 0.819 | 0.5072647 | +137 | -6 | -1395 | + | 8 | -496 | -29 | 0.5070866 |
| 138 | 3 48 | 33.058 | 2.34 | 17 | 28.84 | 0.33 | 0.818 | 0.5076786 | 137 | 8 | 1413 | | 8 | 468 | 29 | 0.5075013 |
| 139 | 4 42 | 34.546 | 2.34 | 15 | 29.15 | 0.33 | 0.817 | 0.5073430 | 137 | 6 | 1428 | | 8 | 495 | 29 | 0.5071617 |
| 137 | 5 41 | 34.099 | 2.34 | 14 | 29.38 | 0.33 | 0.816 | 0.5074407 | 137 | 5 | 1440 | | 8 | 485 | 29 | 0.5072593 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072522 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072531 |
| 2-3 June, 1904. | | | | | | | | | | | | | | | | |
| 137 | 15 3 | 33.973 | +2.90 | 15 | 28.21 | -0.24 | 0.826 | 0.5074687 | -170 | -6 | -1382 | - | 6 | -491 | -29 | 0.5072603 |
| 139 | 16 1 | 34.409 | 2.90 | 16 | 27.91 | 0.24 | 0.827 | 0.5073727 | 170 | 7 | 1368 | | 6 | 501 | 29 | 0.5071646 |
| 138 | 16 58 | 32.933 | 2.90 | 14 | 27.65 | 0.24 | 0.828 | 0.5077081 | 170 | 5 | 1355 | | 6 | 474 | 29 | 0.5075042 |
| 140 | 17 53 | 34.773 | 2.90 | 14 | 27.54 | 0.24 | 0.827 | 0.5072946 | 170 | 5 | 1349 | | 6 | 501 | 29 | 0.5070886 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072544 |
| 137 | 3 0 | 33.985 | +2.90 | 14 | 28.63 | -0.06 | 0.819 | 0.5074660 | -170 | -5 | -1403 | - | 2 | -486 | -29 | 0.5072565 |
| 139 | 3 53 | 34.415 | 2.90 | 16 | 28.88 | 0.06 | 0.820 | 0.5073713 | 170 | 7 | 1415 | | 2 | 497 | 29 | 0.5071593 |
| 138 | 4 54 | 32.927 | 2.90 | 16 | 28.58 | 0.06 | 0.823 | 0.5077096 | 170 | 7 | 1400 | | 2 | 471 | 29 | 0.5075017 |
| 140 | 5 50 | 34.763 | 2.90 | 14 | 28.69 | 0.06 | 0.820 | 0.5072963 | 170 | 5 | 1406 | | 2 | 497 | 29 | 0.5070854 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072507 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072526 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|-----------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 3-4 June, 1904. | | | | | | | | | | | | | | | | |
| 140 | 15 0 | 34.778 | +2.99 | 14 | 27.74 | -0.26 | 0.826 | 0.5072932 | -176 | -5 | -1359 | -6 | -501 | -29 | 0.5070856 | |
| 138 | 15 57 | 32.948 | 2.99 | 15 | 27.49 | 0.26 | 0.827 | 0.5077047 | 176 | 6 | 1347 | 6 | 473 | 29 | 0.5075010 | |
| 139 | 16 52 | 34.436 | 2.99 | 16 | 27.24 | 0.26 | 0.827 | 0.5073667 | 176 | 7 | 1335 | 6 | 501 | 29 | 0.5071613 | |
| 137 | 17 47 | 34.011 | 2.99 | 15 | 27.02 | 0.26 | 0.828 | 0.5074601 | 176 | 6 | 1324 | 6 | 492 | 29 | 0.5072568 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072512 |
| 140 | 3 6 | 34.776 | +2.99 | 15 | 28.39 | +0.52 | 0.818 | 0.5072937 | -176 | -6 | -1391 | +13 | -496 | -29 | 0.5070852 | |
| 138 | 4 7 | 32.930 | 2.99 | 16 | 28.95 | 0.52 | 0.814 | 0.5077090 | 176 | 7 | 1419 | 13 | 466 | 29 | 0.5075006 | |
| 139 | 5 4 | 34.399 | 2.99 | 16 | 29.47 | 0.52 | 0.813 | 0.5073750 | 176 | 7 | 1444 | 13 | 493 | 29 | 0.5071614 | |
| 137 | 6 6 | 33.947 | 2.99 | 16 | 29.94 | 0.52 | 0.811 | 0.5074745 | 176 | 7 | 1467 | 13 | 482 | 29 | 0.5072597 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072517 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072514 |
| 4-5 June, 1904. | | | | | | | | | | | | | | | | |
| 139 | 15 1 | 34.390 | +3.43 | 15 | 28.80 | -0.14 | 0.823 | 0.5073768 | -201 | -6 | -1411 | -4 | -499 | -29 | 0.5071618 | |
| 137 | 15 58 | 33.956 | 3.43 | 14 | 28.48 | 0.14 | 0.823 | 0.5074726 | 201 | 5 | 1396 | 4 | 489 | 29 | 0.5072602 | |
| 140 | 16 57 | 34.750 | 3.43 | 15 | 28.45 | 0.14 | 0.822 | 0.5072993 | 201 | 6 | 1394 | 4 | 498 | 29 | 0.5070861 | |
| 138 | 17 54 | 32.923 | 3.43 | 16 | 28.28 | 0.14 | 0.823 | 0.5077108 | 201 | 7 | 1386 | 4 | 471 | 29 | 0.5075010 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072523 |
| 139 | 3 13 | 34.403 | +3.43 | 15 | 29.16 | +0.43 | 0.814 | 0.5073740 | -201 | -6 | -1429 | +11 | -493 | -29 | 0.5071593 | |
| 137 | 4 7 | 33.953 | 3.43 | 15 | 29.62 | 0.43 | 0.813 | 0.5074731 | 201 | 6 | 1451 | 11 | 483 | 29 | 0.5072572 | |
| 140 | 5 3 | 34.729 | 3.43 | 15 | 30.07 | 0.43 | 0.811 | 0.5073036 | 201 | 6 | 1473 | 11 | 491 | 29 | 0.5070847 | |
| 138 | 6 4 | 32.888 | 3.43 | 14 | 30.43 | 0.43 | 0.810 | 0.5077190 | 201 | 5 | 1491 | 11 | 463 | 29 | 0.5075012 | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072506 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072515 |

The value of g at Dehra Dun.

As Dehra Dún is to be the Base station for all the Indian Pendulum work, a value of g must be adopted for it in terms of which g at all other stations shall be expressed.

At Kew, where the value 981·200 has been accepted, we have (*Vide* Chap. I) the following times of vibration of the pendulums:—

| | | | | | |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| Pendulum | 137 | 138 | 139 | 140 | Mean |
| Time of vibration | 0·5067070 | 0·5069490 | 0·5066104 | 0·5065339 | 0·5067001 |

At Dehra Dún in January and February 1904, we have the following values:—

Table II. Time of Vibration at Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| 1904 | <i>s</i> | <i>s</i> | <i>s</i> | <i>s</i> | <i>s</i> |
| January ... 25-26 | 0·5072600 | 0·5075013 | 0·5071630 | 0·5070870 | 0·5072528 |
| „ ... 26-27 | 0·5072606 | 0·5075014 | 0·5071635 | 0·5070867 | 0·5072530 |
| „ ... 29-30 | 0·5072597 | 0·5075018 | 0·5071621 | 0·5070862 | 0·5072525 |
| February ... 3-4 | 0·5072591 | 0·5075014 | 0·5071620 | 0·5070866 | 0·5072523 |
| „ ... 4-5 | 0·5072605 | 0·5075022 | 0·5071627 | 0·5070871 | 0·5072531 |
| „ ... 5-6 | 0·5072596 | 0·5075017 | 0·5071625 | 0·5070876 | 0·5072528 |
| Mean ... | 0·5072599 | 0·5075016 | 0·5071626 | 0·5070869 | 0·5072528 |
| Diff. from Kew ... | 5529 | 5526 | 5522 | 5530 | 5527 |

The May and June observations produced another set of values, namely:—

Table III. Time of Vibration at Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| 1904 | <i>s</i> | <i>s</i> | <i>s</i> | <i>s</i> | <i>s</i> |
| May ... 27-29* | 0·5072601 | 0·5075011 | 0·5071614 | 0·5070858 | 0·5072521 |
| June ... 2-3 | 0·5072584 | 0·5075030 | 0·5071620 | 0·5070870 | 0·5072526 |
| „ ... 3-4 | 0·5072582 | 0·5075008 | 0·5071613 | 0·5070854 | 0·5072514 |
| „ ... 4-5 | 0·5072587 | 0·5075011 | 0·5071606 | 0·5070854 | 0·5072515 |
| Mean ... | 0·5072589 | 0·5075015 | 0·5071613 | 0·5070859 | 0·5072519 |
| Diff. from Kew ... | 5519 | 5525 | 5509 | 5520 | 5518 |

There is thus a difference of $9^s \times 10^{-7}$ between the reduced times of vibration of the mean pendulum as determined by the first and second series of observations respectively.

For the deduction of g the first series of values will be used, firstly because these observations were made immediately after the arrival of the pendulums in India, so that there is less probability of any change having taken place in the lengths of the pendulums, and secondly because the average temperature during the January and February swings was very nearly the same as it had been at Kew, whereas during the May and June swings it was much higher.

* As no stars were observed on May 28th the Pendulum observations of 27th, 28th and 29th are treated as one set.

The actual mean temperatures were:—

At Kew (taking account of the combination-weights of the several series of observations) ... 14°·1 C
 At Dehra Dún in January and February ... 13°·4 „
 At Dehra Dún in May and June ... 28°·5 „

The coefficient of the temperature correction is $49^s \times 10^{-7}$: an error of one per cent in this number would thus produce a difference of about $8^s \times 10^{-7}$ between the two values of the time of vibration found at Dehra Dún.

Computing by the formula

$$s_0^2 g_0 = s^2 g$$

and using the figures of Table II, we have for the value of g at Dehra Dún:—

| | | | | |
|------------------|---------|---------|---------|---------|
| Pendulum | 137 | 138 | 139 | 140 |
| g at Dehra Dún | 979·062 | 979·064 | 979·064 | 979·061 |

Mean Value of g at Dehra Dún ... 979·063

For the present the value 979·063 will be adopted, but the determination cannot be considered complete until the pendulums have been taken back to Kew and swung there again.

Values of g at the other stations of 1904.

For the computation of g at the other stations the mean of the two sets of times of vibration at Dehra Dún will be employed.

Table IV. Deduction of g .

| Pendulum | 137 | 138 | 139 | 140 | Mean |
|---------------------------|-----------|-----------|-----------|-----------|-----------|
| Dehra Dun. | | | | | |
| Time of vibration | 0·5072594 | 0·5075016 | 0·5071620 | 0·5070864 | 0·5072524 |
| Madras. | | | | | |
| Time of vibration | 0·5074612 | 0·5077053 | 0·5073646 | 0·5072910 | 0·5074555 |
| Difference from Dehra Dún | +2018 | +2037 | +2026 | +2046 | +2031 |
| g | 978·284 | 978·277 | 978·281 | 978·273 | 978·279 |
| Colaba. | | | | | |
| Time of vibration | 0·5073714 | 0·5076143 | 0·5072738 | 0·5071981 | 0·5073644 |
| Difference from Dehra Dún | +1120 | +1127 | +1118 | +1117 | +1120 |
| g | 978·631 | 978·628 | 978·631 | 978·631 | 978·631 |
| Mussooree (Dunseverick). | | | | | |
| Time of vibration | 0·5073334 | 0·5075764 | 0·5072359 | 0·5071612 | 0·5073267 |
| Difference from Dehra Dún | +740 | +748 | +739 | +748 | +743 |
| g | 978·777 | 978·774 | 978·777 | 978·773 | 978·776 |
| Mussooree (Camel's Back). | | | | | |
| Time of vibration | 0·5073288 | 0·5075719 | 0·5072318 | 0·5071562 | 0·5073222 |
| Difference from Dehra Dún | +694 | +703 | +698 | +698 | +698 |
| g | 978·795 | 978·791 | 978·793 | 978·793 | 978·793 |

The agreement between the results by the different pendulums is on the whole satisfactory, and there is no evidence of a change in the length of any of the pendulums which could not with equal probability be ascribed to accidental error.

Comparison with Theoretical Values.

In Chapter I the steps that have to be taken in order to find the value of the force of gravity at a point above the sea level in a given latitude are enumerated, and the theoretical value, based on an acceleration of 978·000 C. G. S. at sea level at the Equator, was deduced both for Kew and Greenwich, using Mr. Strahan's analysis of the underlying strata. In India it will, at any rate for the present, be more convenient to assume that all masses and strata have a density of 2·8, *i.e.* the mean surface density, and by comparing the observed and computed values of the force of gravity, to ascertain where the actual density exceeds or falls short of this mean.

The difference between the observed and computed values of gravity is therefore the number that we are in search of.

It obviously leads to the same result whether we take the theoretical value for the latitude in question and apply corrections to allow for the height of the station above sea level, or apply these corrections with reversed signs to the observed value and so obtain a number which can be compared with the theoretical value at sea level.

The second is the more convenient procedure, as we thus obtain a series of normal values increasing with the latitude, and independent of the heights of the stations.

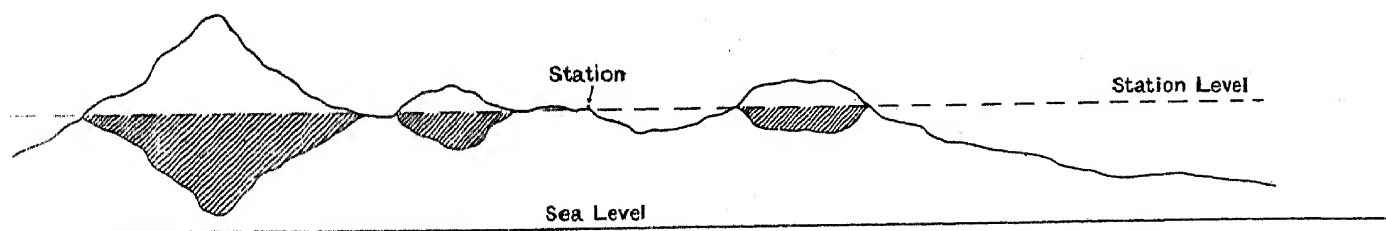
The Orographical Correction.

Correction No. 4 of Chapter I — the orographical correction—must now be dealt with.

The question has been very fully gone into in Volume V of *The Account of the Operations of the G. T. Survey of India*, and the elaborate computation of the correction for Basevi's Mussooree station is given in detail.

The method of treatment which I have adopted is that shewn in para. 6 on p. [187] of the above mentioned volume, but I have throughout first applied the correction which would be appropriate if the station was situated on an infinite plain, and then computed the effect of the inequality of the surface and applied it as a secondary correction. This plan has the advantage that the station is situated in the plane of the upper surface of every zone or block which has to be considered, and this renders the calculations of the attractions very simple.

Masses which stand above the horizontal plane through the station have been imagined to cancel equal masses below it, and thus the station has always been made the highest point of the region, except indeed where it was simpler, as in the case of stations at the foot of hills, to consider that all masses were standing above this plane. The computation is precisely the same in both cases.



In the diagram the shaded portions shew the masses whose attraction on the station is imagined cancelled by that of the hill tops standing above the infinite plain.

The formula employed is the ordinary one for the attraction of a cylinder upon a point in its axis, namely :—

$$A = 2 \pi G \theta \{h + \sqrt{r^2 + c^2} - \sqrt{r^2 + (h+c)^2}\}$$

where

G = acceleration due to the attraction of unit mass at unit distance

θ = density of mass

r = radius of cylinder

h = height of cylinder

c = height of attracted point above the cylinder's upper surface.

Hence the attraction of a hollow cylinder of which the inner radius is r_1 , the outer r_2 , and the height h , on a point situated in its axis and in the plane of its upper surface is

$$Z = 2 \pi G \theta \{r_2 - r_1 - (\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2})\}$$

The attraction of a sphere of radius R and density θ' on a point on its surface is $\frac{4}{3} \pi G \theta' R$, which in the case of the earth is called g .

Hence
$$\frac{Z}{g} = \frac{3}{2} \cdot \frac{\theta}{\theta'} \cdot \frac{1}{R} \{r_2 - r_1 - (\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2})\}$$

and putting
$$\frac{\theta}{\theta'} = \frac{1}{2}, R = 20,900,000 \text{ ft. and } g = 978 \text{ cm}$$

$$Z = 0.000035 \{r_2 - r_1 - (\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2})\} \quad . . . (1)$$

Expanding the roots the expression in brackets becomes

$$\frac{1}{2} h^2 \left(\frac{1}{r_1} - \frac{1}{r_2} \right) - \frac{1}{8} h^4 \left(\frac{1}{r_1^3} - \frac{1}{r_2^3} \right) + \&c.$$

If the second term is not greater than about 2 per cent of the first it may be neglected. When r is equal to $5h$ this condition will ordinarily be satisfied, even where the slopes are very steep.

For the immediate neighbourhood, therefore, of the stations of observation formula (1) has been used, and for the more distant parts

$$Z = 0.000035 \times \frac{1}{2} h^2 \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \quad . . . (2)$$

The Division of the Region into Zones.

No fixed rule has been followed in deciding upon the radii of the successive zones, much depends upon the maps available and upon the steepness of the slopes in the neighbourhood of the station.

If only small scale maps are available, or if the immediate surroundings of the station are fairly level, it is useless to divide up the region into narrow zones.

Mussooree (Dunseverick) was the first station for which the orographical correction had to be computed and I adopted nearly the same radii as Captain Basevi had used in dealing with his station. Some of his radii gave very awkward quantities, and as they possessed no important advantages I abandoned them for round numbers of feet or miles. The number of zones is

certainly unnecessarily large and I kept them for the sake of being able to make a comparison between his method of computing and that which I have adopted, and also in order to see whether my estimation of heights would in any degree accord with his. The maps of the country to the north of Mussooree are extremely defective and the estimation of mean heights was mere guess-work, so there was room for wide divergence of opinion.

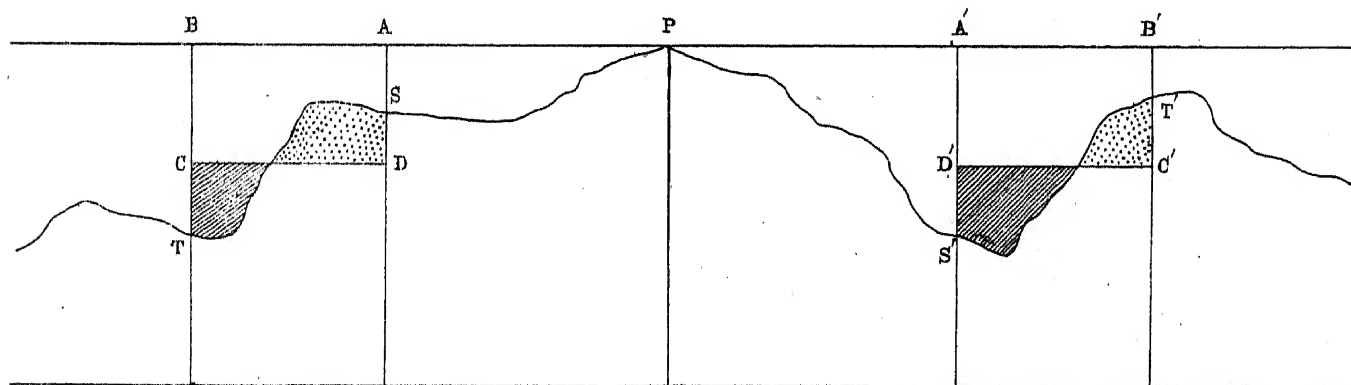
Captain Basevi broke up his zones into blocks by drawing radii at 20° intervals up to a radius of 1320 feet, and thereafter at 10° intervals, thus making 18 and 36 portions respectively; I considered this a needlessly large number and divided my zones into 8 blocks up to a radius of 500 feet, into 12 from 500 feet to 1600 feet, into 16 from 1600 feet to 3 miles, and into 24 from 3 miles to the limits of the investigation.

The mean height of each block was estimated by the best means at hand, but outside a radius of 2 miles a considerable portion of each zone lay in country of which only small scale maps exist. These maps contain very few heights and those that there are almost always refer to peaks, so that the general level is extremely difficult even to guess at.

Estimating the heights of the blocks is by far the longest part of the operation, but even after this has been done the computation, so long as formula (1) has to be used, is sufficiently tedious.

Strictly speaking the effect of each block should be computed and the mean taken: it is not correct to take the mean height of the zone and compute the attraction of the resulting cylinder. This is easily seen from the formula, for $\frac{1}{n} \sum h^2$ is not $= h_0^2$, where h_0 is the mean of n values of h ; the physical meaning is that when we imagine a zone brought to its mean height by levelling, the process implied is the cutting off of all the heights and the filling up of the hollows, thus all the high masses are placed at a lower level and none at a higher. Clearly, the more nearly under the attracted point a mass is, the greater will be the vertical component of its attraction, thus a levelled zone exerts a greater vertical attraction than the natural zone.

The diagram illustrates this: it represents a section through a pendulum station P.



We desire to compute the attraction of the zone enclosed between circles of radius PA and PB respectively, that is to say of the irregular cylindrical mass which is seen in section at

A S T B and A' S' T' B'. If C D D' C' be the surface when the irregularities are all levelled up, we see that we have in effect cut off the two speckled heights and filled up the shaded hollows, and clearly, as far as height is concerned, the shaded portions are more favourably placed for exerting a vertical attraction on P than are the speckled ones. It is true that in the left hand portion the speckled mass has been removed to a greater distance, and that in that respect its effect has been reduced, but the reverse is the case in the right hand portion, and on the whole the lateral displacements will as often be inwards as outwards and no systematic error will be produced.

Thus every time that we take a mean height we increase the vertical attraction of the masses standing on sea level, and decrease that of the difference between the actual mass and the corresponding portion of the cylinder bounded by sea level and by a horizontal plane through the station; that is to say, when we take A B C D instead of A B T S the substitution always involves a loss of efficiency.

In the diagram P is the highest point: to consider the case of a valley station we have only to turn the section upside down; then the masses we have to deal with are those that lie above the plane of the station; here the shaded portions are supposed to be cut off and the speckled ones filled in, which has the effect of reducing the vertical attraction of the mass; that is to say, as before, A B C D is less efficient than A B T S.

The removal of a mass from its actual position to one at the same distance but in any other azimuth has no effect on the vertical component of its attraction, and we may therefore make imaginary displacements of this sort to any extent. I have used this fact in abbreviating the computation of the attraction of those zones for which formula (2) cannot be used.

The method has been to arrange the blocks in order of elevation and then divide them into four equal groups; I have then taken the mean elevation of each group and computed the attraction of the levelled quarter-zones so formed.

This has reduced the labour by one-half in the case of the first 6 zones, by two-thirds in zones 7 to 14, by three-fourths in 15 to 29 and by five-sixths in the remainder, and, as by this means very large vertical displacements have been avoided, a fair approximation to the truth has been obtained.

Limits of the Investigation.

It will be observed that the investigation has not been carried beyond a radius of 35 miles. In Basevi's calculation the enquiry is carried to much greater distances, but the advantage of this may be questioned, while the labour involved must be considerable.

Examining Basevi's figures (p. [173] of Vol. V. *Op. G. T. S.*) we see that the total effect of all the masses standing above sea level is

9.5536 vibrations per day.

If N be the number of vibrations per day made by his pendulums,

$$dg = \frac{2g}{N} dN$$

putting $g = 978$ and $N = 86012$

we have, if $dN = 9.5536$,

$$\begin{aligned} dg &= 0.02274 \times 9.5536 \\ &= 0.2171 \end{aligned}$$

Now the attraction of an infinite plain 6920 feet high is

$$g \times \frac{3}{4} \times \frac{h}{R} = 0.2433$$

Hence the difference obtained, using all Basevi's zones, is

$$0.0262$$

If we omit the zones beyond 35 miles, taking a proportionate part of the zone between 29.4 and 37.6 miles, dN becomes 9.4318 and dg 0.2142, and the difference between this and the attraction of the infinite plain is

$$0.0291$$

Thus by omitting the outer zones a difference of 0.0029 in the orographical correction is produced.

This difference is not very large, its amount is not very certain and yet to obtain it a great deal of trouble must have been taken and many maps must have been examined.

If instead of analysing the country outside the 35-mile radius in detail, we look at it in a general way and assume that a plain 6920 feet high and of indefinite extension occupies the northern half, and that the southern half is all at sea level we shall obtain the following figures.

| | | | cm |
|---|-----|-----|--------|
| Attraction of infinite plain 6920 feet high all round | ... | ... | 0.2433 |
| „ „ disc of same height 35 miles in radius | ... | ... | 0.2378 |
| Difference = attraction of plain outside 35-mile radius | ... | ... | 0.0055 |
| Half difference | ... | ... | 0.0028 |
| Attraction of 35-mile disc + half outer plain | ... | ... | 0.2406 |
| „ „ actual masses within 35-mile radius | ... | ... | 0.2142 |
| Difference = orographical correction | ... | ... | 0.0264 |
| „ „ by Basevi's analysis | ... | ... | 0.0262 |

In this case therefore the approximate method is justified and it will in many instances be found possible to make some simple generalisation which will take sufficient account of all but the nearest masses.

The Effect of Curvature.

No account has so far been taken of the curvature of the earth's surface, nor is it intended to do so. The effect of applying the corrections which are under discussion is to produce a value of g at sea level which shall be comparable with γ_0 the theoretical value depending on the latitude; as we recede from the station the effect of the surface masses, conceived as lying on a plane tangential to the spheroid, becomes rapidly smaller, and at a distance of 100 miles* or so becomes insensible. Up to this distance the effect of the earth's curvature is inappreciable. Beyond this the curvature becomes the most important element in producing a vertical attraction at the station of observation, but the difference in the attraction of such distant masses on the station and on a point at sea level vertically below it is now so small as to be negligible, and it is this difference that is required when we are reducing to sea level. Hence neither for proximate nor for distant masses should the effect of curvature be taken into account.†

* A block 1 mile high occupying 30° of a zone the inner radius of which is 100 miles and the outer infinite, exerts a vertical attraction of 0.000,077 C. G. S. on a station at sea level at the centre of the zone.

† Cf. Vol. V. *Op. G. T. S.* page [189] et. seq. and "Die Schwerkraft im Hochgebirge" by Prof. F. R. Helmert, p. 29.

The Orographical Correction at Mussooree (Dunseverick).

In Tables VI & VII, the figures relating to the orographical correction at Dunseverick are given. Δh is the difference between the height of the quarter-zone, formed according to the method explained above, and the height of the station. In the column with the heading "effect" is shewn the value of the quantity

$$\left\{ r_2 - r_1 - \left(\sqrt{r_2^2 + \Delta h^2} - \sqrt{r_1^2 + \Delta h^2} \right) \right\}$$

this number when multiplied by 0.000035 gives the value of the attraction of a complete cylinder of height Δh , therefore the mean of the four "effects" is the measure of the sum of the attractions of the four quarter-cylinders.

After zone 31 the simpler formula (2) has been used and it has not been necessary to group the blocks, for the computation in full is quite short. Here the quantity "effect" has the same meaning as before: it is equal to

$$\frac{1}{2} \times \frac{\Delta h^2}{n} \times \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \times 0.0001894$$

The factor 0.0001894 is required because here r_1 and r_2 are expressed in miles.

Finally the sum of all the effects is taken, and this, multiplied by 0.000035, is the difference between the attraction of a disc 35 miles in radius and 7129 feet thick and the actual attraction of the existing masses within the same radius.

Table VI. Orographical Correction at Mussooree (Dunseverick).
Height 7129 feet.

| No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect | No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect |
|-------------|--------------|--------------|--------------------------|----------------------------|-------------|-------------|--------------|----------------------------------|------------------------------|------------------------------|-------------|
| | <i>feet</i> | <i>feet</i> | <i>feet</i> | | | | <i>feet</i> | <i>feet</i> | <i>feet</i> | | |
| 1 | 150 | 200 | 5 39 51 58 | 0.0 1.2 2.0 2.6 | 1.5 | 17 | 2000 | 2200 | 339 520 707 895 | 2.6 5.9 10.5 16.0 | 8.8 |
| 2 | 200 | 250 | 26 49 76 96 | 0.4 1.1 2.7 4.0 | 2.1 | 18 | 2200 | 2420 | 394 550 762 955 | 3.3 6.0 11.1 16.7 | 9.3 |
| 3 | 250 | 300 | 31 61 96 129 | 0.3 1.2 2.8 4.7 | 2.3 | 19 | 2420 | 2640 ($\frac{1}{2}$ mile) | 425 599 831 1009 | 3.0 5.9 11.0 15.6 | 8.9 |
| 4 | 300 | 350 | 46 84 121 161 | 0.5 1.6 3.2 5.2 | 2.6 | 20 | 2640 | 3300 ($\frac{3}{4}$ mile) | 478 682 967 1180 | 7.5 17.0 32.7 47.1 | 26.1 |
| 5 | 350 | 400 | 56 119 146 201 | 0.6 2.4 3.4 5.9 | 3.1 | 21 | 3300 | 3960 ($\frac{3}{4}$ mile) | 482 793 1155 1380 | 5.8 15.3 31.3 43.3 | 23.9 |
| 6 | 400 | 500 | 84 151 199 258 | 1.7 5.3 8.7 13.3 | 7.3 | 22 | 3960 | 4620 ($\frac{3}{4}$ mile) | 573 830 1055 1430 | 5.8 12.1 19.2 34.1 | 17.8 |
| 7 | 500 | 600 | 78 186 236 336 | 1.0 5.3 8.2 14.7 | 7.3 | 23 | 4620 | 5280 (1 mile) | 605 963 1242 1493 | 4.9 12.2 19.9 28.2 | 16.3 |
| 8 | 600 | 700 | 93 194 264 379 | 1.1 4.2 7.4 13.7 | 6.6 | 24 | 5280 | 6600 (1 $\frac{1}{2}$ miles) | 830 1130 1405 1580 | 12.9 23.6 35.9 44.8 | 29.3 |
| 9 | 700 | 800 | 96 209 313 441 | 0.9 3.6 7.8 13.7 | 6.5 | 25 | 6600 | 7920 (1 $\frac{1}{2}$ miles) | 855 1255 1605 1880 | 9.2 19.5 31.4 42.4 | 25.6 |
| 10 | 800 | 900 | 119 235 369 499 | 1.0 3.6 8.3 13.9 | 6.7 | 26 | 7920 | 9240 (1 $\frac{1}{2}$ miles) | 830 1455 1780 2205 | 6.2 18.6 27.7 41.8 | 23.6 |
| 11 | 900 | 1000 | 158 264 426 543 | 1.4 3.6 8.7 13.1 | 6.7 | 27 | 9240 | 10560 (2 miles) | 730 1430 2005 2555 | 3.6 13.6 26.4 42.2 | 21.5 |
| 12 | 1000 | 1200 | 179 324 486 631 | 2.8 8.3 17.2 26.6 | 13.7 | 28 | 10560 | 13200 (2 $\frac{1}{2}$ miles) | 580 1430 2680 3180 | 3.2 19.2 65.5 90.8 | 44.7 |
| 13 | 1200 | 1400 | 214 398 526 724 | 2.6 8.8 14.6 25.4 | 12.9 | 29 | 13200 | 15840 (3 miles) | 480 1505 2855 3555 | 1.5 14.2 50.0 76.3 | 35.5 |
| 14 | 1400 | 1600 | 249 436 568 771 | 2.6 8.0 13.0 22.2 | 11.5 | 30 | 15840 | 21120 (4 miles) | 1033 2000 2850 3783 | 8.4 31.2 63.0 109.4 | 53.0 |
| 15 | 1600 | 1800 | 301 430 586 821 | 3.2 6.1 10.7 20.0 | 10.0 | 31 | 21120 | 26400 (5 miles) | 1200 1967 3033 4067 | 6.8 18.2 43.0 76.6 | 36.2 |
| 16 | 1800 | 2000 | 304 477 642 864 | 2.6 6.0 11.0 17.9 | 9.4 | | | | | | |

*Table VII. Orographical Correction at Mussooree (Dunseverick).
Height 7129 feet.*

| Zone 32 | | Zone 33 | | Zone 34 | | Zone 35 | | Zone 36 | |
|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|
| r_1 | 5 Miles | r_1 | 6 Miles | r_1 | 7 Miles | r_1 | 8½ Miles | r_1 | 10 Miles |
| r_2 | 6 " | r_2 | 7 " | r_2 | 8½ " | r_2 | 10 " | r_2 | 12 " |
| $\frac{1}{r_1}$ | 0.200 | $\frac{1}{r_1}$ | 0.167 | $\frac{1}{r_1}$ | 0.143 | $\frac{1}{r_1}$ | 0.118 | $\frac{1}{r_1}$ | 0.100 |
| $\frac{1}{r_2}$ | 0.167 | $\frac{1}{r_2}$ | 0.143 | $\frac{1}{r_2}$ | 0.118 | $\frac{1}{r_2}$ | 0.100 | $\frac{1}{r_2}$ | 0.083 |
| Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ |
| <i>feet</i> | | <i>feet</i> | | <i>feet</i> | | <i>feet</i> | | <i>feet</i> | |
| 800 | 64 | 600 | 36 | 2600 | 676 | 2600 | 676 | 1100 | 121 |
| 300 | 9 | 500 | 25 | 900 | 81 | 700 | 49 | 1100 | 121 |
| 1100 | 121 | 1300 | 169 | 700 | 49 | 1100 | 121 | 1500 | 225 |
| 2100 | 441 | 1600 | 256 | 1400 | 196 | 1400 | 196 | 600 | 36 |
| 1600 | 256 | 2100 | 441 | 1800 | 324 | 1400 | 196 | 1100 | 121 |
| 1300 | 169 | 1900 | 361 | 1700 | 289 | 1600 | 256 | 1400 | 196 |
| 800 | 64 | 800 | 64 | 800 | 64 | 700 | 49 | 700 | 49 |
| 1700 | 289 | 2100 | 441 | 300 | 9 | 1100 | 121 | 1300 | 169 |
| 2400 | 576 | 2900 | 841 | 1600 | 256 | 2600 | 676 | 1600 | 256 |
| 3500 | 1225 | 3900 | 1521 | 3100 | 961 | 3600 | 1296 | 3100 | 961 |
| 4200 | 1764 | 4300 | 1849 | 4300 | 1849 | 4500 | 2025 | 4300 | 1849 |
| 4500 | 2025 | 4600 | 2116 | 4700 | 2209 | 4900 | 2401 | 5000 | 2500 |
| 4300 | 1849 | 4500 | 2025 | 4700 | 2209 | 4900 | 2401 | 5000 | 2500 |
| 4400 | 1936 | 4600 | 2116 | 4900 | 2401 | 5100 | 2601 | 5100 | 2601 |
| 4200 | 1764 | 4500 | 2025 | 4800 | 2304 | 5100 | 2601 | 5300 | 2809 |
| 4200 | 1764 | 4500 | 2025 | 4800 | 2304 | 5000 | 2500 | 5200 | 2704 |
| 3800 | 1444 | 4200 | 1764 | 4500 | 2025 | 4900 | 2401 | 5100 | 2601 |
| 2600 | 676 | 3100 | 961 | 3800 | 1444 | 4400 | 1936 | 4900 | 2401 |
| 600 | 36 | 600 | 36 | 2600 | 676 | 3600 | 1296 | 4500 | 2025 |
| 1600 | 256 | 600 | 36 | 3500 | 1225 | 3900 | 1521 | 4300 | 1849 |
| 3600 | 1296 | 3900 | 1521 | 2800 | 784 | 2300 | 529 | 3100 | 961 |
| 3100 | 961 | 3600 | 1296 | 4100 | 1681 | 2100 | 441 | 2100 | 441 |
| 1100 | 121 | 1600 | 256 | 3100 | 961 | 3100 | 961 | 2800 | 784 |
| 600 | 36 | 1600 | 256 | 3100 | 961 | 2100 | 441 | 2100 | 441 |
| Mean | 798 | Mean | 935 | Mean | 1081 | Mean | 1154 | Mean | 1197 |
| Effect | 24.9 | Effect | 21.3 | Effect | 25.6 | Effect | 19.7 | Effect | 19.3 |

Table VII. (Continued).

| Zone 37 | | Zone 38 | | Zone 39 | | Zone 40 | | Zone 41 | | Zone 42 | |
|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|
| r_1 | 12 Miles | r_1 | 14 Miles | r_1 | 17 Miles | r_1 | 20 Miles | r_1 | 25 Miles | r_1 | 30 Miles |
| r_2 | 14 " | r_2 | 17 " | r_2 | 20 " | r_2 | 25 " | r_2 | 30 " | r_2 | 35 " |
| $\frac{1}{r_1}$ | 0.083 | $\frac{1}{r_1}$ | 0.071 | $\frac{1}{r_1}$ | 0.059 | $\frac{1}{r_1}$ | 0.050 | $\frac{1}{r_1}$ | 0.040 | $\frac{1}{r_1}$ | 0.033 |
| $\frac{1}{r_2}$ | 0.071 | $\frac{1}{r_2}$ | 0.059 | $\frac{1}{r_2}$ | 0.050 | $\frac{1}{r_2}$ | 0.040 | $\frac{1}{r_2}$ | 0.033 | $\frac{1}{r_2}$ | 0.029 |
| Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ | Δh | $(\Delta h)^2 \times 10^{-4}$ |
| <i>feet</i> | | <i>feet</i> | | <i>feet</i> | | <i>feet</i> | | <i>feet</i> | | <i>feet</i> | |
| 3100 | 961 | 1600 | 256 | 1100 | 121 | 800 | 64 | 1100 | 121 | 900 | 81 |
| 1600 | 256 | 900 | 81 | 1100 | 121 | 800 | 64 | 1600 | 256 | 900 | 81 |
| 500 | 25 | 1600 | 256 | 1100 | 121 | 600 | 36 | 1100 | 121 | 1100 | 121 |
| 1100 | 121 | 1100 | 121 | 2100 | 441 | 2100 | 441 | 1600 | 256 | 2100 | 441 |
| 800 | 64 | 1600 | 256 | 3100 | 961 | 900 | 81 | 1100 | 121 | 1600 | 256 |
| 1100 | 121 | 1600 | 256 | 2600 | 676 | 2100 | 441 | 1600 | 256 | 1600 | 256 |
| 1100 | 121 | 1000 | 100 | 1600 | 256 | 2100 | 441 | 1100 | 121 | 1600 | 256 |
| 1300 | 169 | 1600 | 256 | 2100 | 441 | 1600 | 256 | 1600 | 256 | 1100 | 121 |
| 1300 | 169 | 2100 | 441 | 1600 | 256 | 2100 | 441 | 1600 | 256 | 1100 | 121 |
| 1600 | 256 | 3100 | 961 | 3400 | 1156 | 4100 | 1681 | 4100 | 1681 | 1100 | 121 |
| 3600 | 1296 | 4900 | 2401 | 5200 | 2704 | 5400 | 2916 | 5900 | 3481 | 4600 | 2116 |
| 4300 | 1849 | 4900 | 2401 | 5400 | 2916 | 5700 | 3249 | 5300 | 2809 | 5800 | 3364 |
| 5200 | 2704 | 4800 | 2304 | 4900 | 2401 | 4800 | 2304 | 5500 | 3025 | 5700 | 3249 |
| 5200 | 2704 | 4600 | 2116 | 4600 | 2116 | 5600 | 3136 | 5800 | 3364 | 6000 | 3600 |
| 5100 | 2601 | 5000 | 2500 | 4600 | 2116 | 5200 | 2704 | 5800 | 3364 | 6000 | 3600 |
| 5300 | 2809 | 5200 | 2704 | 4700 | 2209 | 4700 | 2209 | 5700 | 3249 | 6000 | 3600 |
| 5300 | 2809 | 5500 | 3025 | 5400 | 2916 | 4700 | 2209 | 5400 | 2916 | 5900 | 3481 |
| 5300 | 2809 | 5500 | 3025 | 5600 | 3136 | 5200 | 2704 | 5700 | 3249 | 5700 | 3249 |
| 5200 | 2704 | 5500 | 3025 | 5600 | 3136 | 5300 | 2809 | 4800 | 2304 | 5300 | 2809 |
| 5400 | 2916 | 4100 | 1681 | 4100 | 1681 | 2100 | 441 | 1600 | 256 | 4600 | 2116 |
| 4100 | 1681 | 1600 | 256 | 3100 | 961 | 3600 | 1296 | 1500 | 225 | 1200 | 144 |
| 2600 | 676 | 2100 | 441 | 1600 | 256 | 1000 | 100 | 900 | 81 | 500 | 25 |
| 2600 | 676 | 2100 | 441 | 1600 | 256 | 800 | 64 | 900 | 81 | 2100 | 441 |
| 2600 | 676 | 1600 | 256 | 1600 | 256 | 1000 | 100 | 900 | 81 | 2100 | 441 |
| Mean | 1299 | Mean | 1232 | Mean | 1317 | Mean | 1258 | Mean | 1330 | Mean | 1420 |
| Effect | 14.8 | Effect | 14.0 | Effect | 11.2 | Effect | 11.9 | Effect | 8.8 | Effect | 5.4 |

Total effect of all zones = 667.6

Attraction = $667.6 \times 0.000035 = 0.0234$

For the region lying outside the 35-mile radius the same assumption may be made as was suggested in the case of Basevi's station on the Camel's Back, namely, that the northern half consists of a plain at the level of the station and that the southern half is at sea level.

| | | | |
|---|-----|-----|--------|
| Attraction of infinite plain 7129 feet high | ... | ... | 0.2510 |
| Attraction of disc of 35-mile radius 7129 feet high | ... | ... | .2447 |
| Difference | ... | ... | .0063 |
| Half difference | ... | ... | .0032 |

Hence, for the reduction to sea level we have

$$g \frac{2h}{R} = + 0.668$$

$$g \frac{3}{4} \frac{h}{R} = - 0.251$$

| | |
|---|---------|
| Orographical correction within a radius of 35 miles | + 0.023 |
| " " beyond a radius of 35 miles | + 0.003 |
| Total ... | + 0.443 |

Orographical Correction at Mussooree (Camel's Back).

Although the correction for the Camel's Back station has been so fully discussed in Volume V "*Op. G.T.S.*" yet, for the sake of the valuable test which would be afforded by a comparison of the result of an independent computation with that obtained by Basevi, I redivided the surrounding area into zones and blocks and estimated the heights afresh.

As the distance between the Camel's Back and Dunseverick is so small (under 1 mile) I only carried the process to a radius of 3 miles, and beyond that assumed that the blocks coincided with those appertaining to the zones round Dunseverick, and accepted the heights which had already been estimated. As the Camel's Back station is 200 feet lower than Dunseverick the differences in height, which enter into the computation, have of course been altered.

Tables VIII and IX contain the results arrived at; but the details of the outer zones have been given more concisely than was done in the case of Dunseverick.

Table VIII. Orographical Correction at Mussooree (Camel's Back).

Height 6924 feet.

(Computation using new estimation of heights).

| No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect | No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect |
|-------------|--------------|--------------|--------------------------|---------------------|-------------|-------------|--------------|----------------------------------|------------------------------|---------------------|-------------|
| | <i>feet</i> | <i>feet</i> | | | | | <i>feet</i> | <i>feet</i> | | | |
| 1 | 150 | 200 | 24 64 94 117 | 1 3 6 8 | 4.5 | 17 | 2000 | 2200 | 405 702 824 924 | 4 11 14 17 | 11.5 |
| 2 | 200 | 250 | 49 87 119 154 | 1 3 6 8 | 4.5 | 18 | 2200 | 2420 | 422 674 862 999 | 3 9 14 18 | 11.0 |
| 3 | 250 | 300 | 62 104 139 194 | 2 3 5 9 | 4.8 | 19 | 2420 | 2640 ($\frac{1}{2}$ mile) | 412 674 962 1086 | 3 7 14 19 | 10.8 |
| 4 | 300 | 350 | 69 114 162 209 | 1 3 5 8 | 4.3 | 20 | 2640 | 3300 ($\frac{3}{8}$ mile) | 412 812 1087 1249 | 6 24 41 52 | 30.8 |
| 5 | 350 | 400 | 82 134 184 232 | 2 3 5 8 | 4.5 | 21 | 3300 | 3960 ($\frac{1}{2}$ mile) | 349 824 1074 1424 | 3 16 27 46 | 23.0 |
| 6 | 400 | 500 | 107 167 212 254 | 3 7 10 13 | 8.3 | 22 | 3960 | 4620 ($\frac{1}{2}$ mile) | 274 599 1174 1612 | 2 6 23 43 | 18.5 |
| 7 | 500 | 600 | 159 197 242 314 | 4 5 8 13 | 7.5 | 23 | 4620 | 5280 (1 mile) | 262 549 1212 1724 | 0 4 19 37 | 15.0 |
| 8 | 600 | 700 | 209 237 277 307 | 4 6 8 13 | 7.8 | 24 | 5280 | 6600 (1 $\frac{1}{2}$ miles) | 259 624 1324 2024 | 1 8 32 72 | 28.3 |
| 9 | 700 | 800 | 217 264 331 401 | 4 6 8 12 | 7.5 | 25 | 6600 | 7920 (1 $\frac{1}{2}$ miles) | 237 874 1424 2499 | 0 10 25 72 | 26.8 |
| 10 | 800 | 900 | 182 309 386 431 | 2 6 9 11 | 7.0 | 26 | 7920 | 9240 (1 $\frac{1}{2}$ miles) | 324 974 1599 2674 | 1 9 23 60 | 23.3 |
| 11 | 900 | 1000 | 149 344 427 482 | 1 6 9 11 | 6.8 | 27 | 9240 | 10560 (2 miles) | 349 974 1874 2699 | 1 6 23 48 | 19.5 |
| 12 | 1000 | 1200 | 159 402 479 577 | 3 12 17 23 | 13.8 | 28 | 10560 | 13200 (2 $\frac{1}{2}$ miles) | 499 1649 2174 2999 | 3 25 43 82 | 38.3 |
| 13 | 1200 | 1400 | 169 479 552 714 | 2 12 16 24 | 13.5 | 29 | 13200 | 15840 (3 miles) | 349 1624 2299 3049 | 1 17 33 57 | 27.0 |
| 14 | 1400 | 1600 | 214 544 604 816 | 2 12 15 24 | 13.3 | 30 | 15840 | 21120 (4 miles) | 830 1800 2650 3580 | 5 25 55 98 | 45.8 |
| 15 | 1600 | 1800 | 298 508 705 830 | 3 8 16 21 | 12.0 | 31 | 21120 | 26400 (5 miles) | 1000 1760 2830 3860 | 5 15 37 69 | 31.5 |
| 16 | 1800 | 2000 | 347 589 769 912 | 3 9 14 20 | 11.5 | | | | | | |

Table IX. Orographical Correction at Mussooree (Camel's Back).

Height 6924 feet.

(Computation using new estimation of heights).

| No. of Zone | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|----------------|----------------|----------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| r_1 r_2 | 5 miles 6 " | 6 miles 7 " | 7 miles 8½ " | 8½ miles 10 " | 10 miles 12 " | 12 miles 14 " | 14 miles 17 " | 17 miles 20 " | 20 miles 25 " | 25 miles 30 " | 30 miles 35 " |
| | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet |
| | 600 | 400 | 2400 | 2400 | 900 | 1400 | 1400 | 900 | 600 | 900 | 700 |
| | 100 | 300 | 700 | 500 | 900 | 300 | 700 | 900 | 600 | 1400 | 900 |
| | 900 | 1100 | 500 | 900 | 1300 | 900 | 1400 | 900 | 400 | 900 | 1900 |
| | 1900 | 1400 | 1200 | 1200 | 400 | 600 | 900 | 1900 | 1900 | 1400 | 1400 |
| | 1400 | 1900 | 1600 | 1200 | 900 | 900 | 1400 | 2900 | 700 | 900 | 1400 |
| | 1100 | 1700 | 1500 | 1400 | 1200 | 900 | 1400 | 2400 | 1900 | 1400 | 1400 |
| | 600 | 600 | 600 | 500 | 500 | 1100 | 800 | 1400 | 1900 | 900 | 900 |
| | 1500 | 1900 | 100 | 900 | 1100 | 1100 | 1400 | 1900 | 1400 | 1400 | 900 |
| | 2200 | 2700 | 1400 | 2400 | 1400 | 1400 | 1900 | 1400 | 1900 | 1400 | 900 |
| | 3300 | 3700 | 2900 | 3400 | 2900 | 3400 | 2900 | 3200 | 3900 | 3900 | 4400 |
| | 4000 | 4100 | 4100 | 4300 | 4100 | 4100 | 4700 | 5000 | 5200 | 5700 | 5600 |
| | 4300 | 4400 | 4500 | 4700 | 4800 | 5000 | 4700 | 5200 | 5500 | 5100 | 5500 |
| | 4100 | 4300 | 4500 | 4700 | 4800 | 5000 | 4600 | 4700 | 4600 | 5300 | 5800 |
| | 4200 | 4400 | 4700 | 4900 | 4900 | 4900 | 4400 | 4400 | 5400 | 5600 | 5800 |
| | 4000 | 4300 | 4600 | 4900 | 5100 | 5100 | 4800 | 4400 | 5000 | 5600 | 5800 |
| | 4000 | 4300 | 4600 | 4800 | 5000 | 5100 | 5000 | 4500 | 4500 | 5500 | 5700 |
| | 3600 | 4000 | 4300 | 4700 | 4900 | 5100 | 5300 | 5200 | 4500 | 5200 | 5500 |
| | 2400 | 2900 | 3600 | 4200 | 4700 | 5000 | 5300 | 5400 | 5000 | 5500 | 5100 |
| | 400 | 400 | 2400 | 3400 | 4300 | 5200 | 5300 | 5400 | 5100 | 4600 | 4400 |
| | 1400 | 400 | 3300 | 3700 | 4100 | 3900 | 3900 | 3900 | 1900 | 1400 | 1000 |
| | 3400 | 3700 | 2600 | 2100 | 2900 | 2400 | 1400 | 2900 | 3400 | 1300 | 300 |
| | 2900 | 3400 | 3900 | 1900 | 1900 | 2400 | 1900 | 1400 | 800 | 700 | 1900 |
| | 900 | 1400 | 2900 | 2900 | 2600 | 2400 | 1900 | 1400 | 600 | 700 | 1900 |
| | 400 | 1400 | 2900 | 1900 | 1900 | 2900 | 1400 | 1400 | 800 | 700 | 700 |
| Effect | 22.0 | 18.9 | 22.9 | 17.6 | 17.4 | 13.3 | 12.6 | 10.1 | 10.8 | 8.0 | 4.9 |

Total effect of all zones = 651.2
Attraction = 651.2 \times 0.000035 = 0.0228

It has already been shewn on p. 57 that for the irregularities beyond the 35-mile radius an allowance of 0.0028 may be made; my estimations of height therefore yield a total orographical correction of

$$0.0228 + 0.0028 = 0.0256$$

Basevi's result was 0.0262, so that the agreement is better than could have been expected.

For the Camel's Back Station the reduction to sea level is as follows:—

| | | | |
|---|-------------------|---|---------|
| | $g \frac{2h}{R}$ | = | + 0.649 |
| | $g \frac{3h}{4R}$ | = | — 0.243 |
| Orographical correction within 35-mile radius | | | + 0.023 |
| „ „ beyond 35-mile „ | | | + 0.003 |
| | Total | | + 0.432 |

Recomputation using Basevi's heights.

The method which Col. Herschel devised for reducing the labour of the computation* was not the same as that which I have adopted and I have considered it worth while to recompute the orographical correction for Mussooree (Camel's Back), using Captain Basevi's heights and my method.

The results are given in Tables X and XI.

* *Vide* Vol. V *Op. G. T. S.* p. [164]

*Table X. Orographical Correction at Mussooree (Camel's Back).
Height 6924 feet.
(Recomputation using Basevi's heights).*

| No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect | No. of Zone | Inner Radius | Outer Radius | Δh | Effect | Mean Effect |
|-------------|--------------|--------------|---------------------------|-----------------------------|-------------|-------------|--------------|----------------------|------------------------------|-----------------------------|-------------|
| | <i>feet</i> | <i>feet</i> | | | | | <i>feet</i> | <i>feet</i> | | | |
| 1 | 50 | 100 | 7 16 27 | 0.3 1.2 3.2 | 1.6 | 21 | 2200 | 2420 | 434 689 859 1095 | 3.8 9.2 13.9 21.2 | 12.0 |
| 2 | 100 | 150 | 12 32 64 | 0.2 1.6 5.6 | 2.5 | 22 | 2420 | 2640 (0.5 mile) | 465 727 926 1154 | 3.7 8.5 13.4 19.9 | 11.4 |
| 3 | 150 | 200 | 22 49 97 | 0.4 1.9 6.3 | 2.9 | 23 | 2640 | 3080 (0.583 mile) | 449 812 1030 1212 | 5.3 16.9 26.1 35.0 | 20.8 |
| 4 | 200 | 250 | 32 65 115 | 0.5 2.0 5.5 | 2.7 | 24 | 3080 | 3520 (0.667 mile) | 399 824 1135 1289 | 3.2 13.1 24.0 30.3 | 17.7 |
| 5 | 250 | 300 | 38 90 140 | 0.5 2.5 5.4 | 2.8 | 25 | 3520 | 3960 (0.75 mile) | 368 732 1159 1393 | 2.1 8.2 19.8 27.7 | 14.5 |
| 6 | 300 | 350 | 55 117 163 | 0.7 3.0 5.3 | 3.0 | 26 | 3960 | 4620 (0.875 mile) | 273 605 1110 1508 | 1.3 6.5 21.1 37.5 | 16.6 |
| 7 | 350 | 400 | 77 147 187 | 1.1 3.5 5.2 | 3.3 | 27 | 4620 | 5280 (1 mile) | 202 510 1070 1562 | 0.5 3.5 14.9 30.7 | 12.4 |
| 8 | 400 | 500 | 102 187 227 | 2.5 7.8 10.8 | 7.0 | 28 | 5280 | 6600 (1.25 ml.) | 334 703 1170 1876 | 2.1 9.3 25.2 62.0 | 24.7 |
| 9 | 500 | 600 | 142 232 280 | 3.2 7.9 11.0 | 7.4 | 29 | 6600 | 7920 (1.50 ml.) | 274 872 1565 2353 | 1.0 9.5 29.9 64.8 | 26.3 |
| 10 | 600 | 700 | 180 275 355 | 3.6 7.9 12.3 | 7.9 | 30 | 7920 | 9240 (1.75 ml.) | 320 1270 1842 2692 | 1.0 14.3 29.6 60.8 | 26.4 |
| 11 | 700 | 800 | 202 323 417 | 3.5 8.1 12.6 | 8.1 | 31 | 9240 | 10560 (2 miles) | 592 1531 2242 2998 | 2.3 11.9 32.7 56.9 | 26.0 |
| 12 | 800 | 900 | 208 362 472 | 3.9 8.0 12.6 | 8.2 | 32 | 10560 | 13485 (2.554 ml.) | 787 1720 2487 3198 | 6.1 29.8 61.5 99.5 | 49.2 |
| 13 | 900 | 1000 | 195 403 548 | 2.1 7.9 13.4 | 7.8 | 33 | 13485 | 17218 (3.261 ml.) | 709 1898 2709 3375 | 4.0 28.6 57.6 88.2 | 44.6 |
| 14 | 1000 | 1100 | 197 453 615 | 1.7 8.2 13.8 | 7.9 | 34 | 17218 | 21991 (4.165 ml.) | 831 2131 2775 3476 | 4.3 28.3 47.8 74.4 | 38.7 |
| 15 | 1100 | 1210 | 220 500 675 | 2.0 9.1 15.0 | 8.7 | 35 | 21991 | 28079 (5.318 ml.) | 1220 2287 3020 3809 | 7.3 25.6 44.5 70.2 | 36.9 |
| 16 | 1210 | 1320 | 240 535 725 | 2.0 8.7 14.6 | 8.4 | | | | | | |
| 17 | 1320 | 1540 | 187 499 661 848 | 1.9 12.4 20.4 30.9 | 16.4 | | | | | | |
| 18 | 1540 | 1760 | 272 519 710 921 | 3.0 10.2 18.0 28.0 | 14.8 | | | | | | |
| 19 | 1760 | 1980 | 352 578 778 985 | 3.9 9.9 16.9 25.3 | 14.0 | | | | | | |
| 20 | 1980 | 2200 | 373 629 832 1035 | 3.4 9.3 15.6 22.9 | 12.8 | | | | | | |

Effect of zones up to a radius of 5.318 miles = 526.4

$$\text{Attraction} = 526.4 \times 0.000035 = 0.0184$$

*Table XI. Orographical Correction at Mussooree (Camel's Back).
(Recomputation using Basevi's heights.)*

| No. of Zone | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|-------------------|----------------------|----------------------|-----------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| r_1 r_2 | 5·318 ml. 6·791 „ | 6·791 ml. 8·672 „ | 8·672 ml. 10·075 „ | 10·075 ml. 14·142 „ | 14·142 ml. 18·059 „ | 18·059 ml. 23·061 „ | 23·061 ml. 29·449 „ | 29·449 ml. 37·606 „ |
| | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> |
| | 1920 | 2420 | 2420 | 2920 | 3220 | 2920 | 1920 | 920 |
| | 1420 | 1920 | 1920 | 1920 | 1920 | 2420 | 2420 | 920 |
| | 1920 | 420 | 420 | 920 | 1420 | 1420 | 920 | 920 |
| | 1720 | 1420 | 1080 | 920 | 1920 | 1420 | 920 | 80 |
| | 1920 | 2220 | 420 | 920 | 2420 | 2920 | 2420 | 1080 |
| | 2220 | 2220 | 1420 | 1920 | 2920 | 2920 | 1920 | 920 |
| | 2520 | 2220 | 1620 | 1420 | 3420 | 2420 | 920 | 1080 |
| | 2220 | 2420 | 1820 | 1420 | 3420 | 2920 | 3420 | 920 |
| | 1220 | 1420 | 1920 | 1420 | 2920 | 3920 | 3420 | 2920 |
| | 220 | 80 | 1420 | 1420 | 920 | 3420 | 2420 | 2920 |
| | 220 | 220 | 80 | 80 | 1420 | 2920 | 3920 | 2920 |
| | 1420 | 1920 | 1920 | 2920 | 2920 | 1920 | 3920 | 3920 |
| | 1920 | 2920 | 2920 | 3420 | 3420 | 3420 | 1920 | 3920 |
| | 2920 | 3420 | 3420 | 3920 | 3920 | 2920 | 3920 | 4420 |
| | 3620 | 3720 | 3920 | 4220 | 4420 | 4420 | 4920 | 4920 |
| | 3920 | 3920 | 4420 | 4220 | 4920 | 5420 | 5820 | 5420 |
| | 4020 | 4420 | 4620 | 4920 | 5220 | 5420 | 5620 | 5620 |
| | 3920 | 4520 | 4720 | 5020 | 5020 | 5220 | 5220 | 5620 |
| | 4020 | 4420 | 4620 | 4920 | 4920 | 4820 | 5420 | 5820 |
| | 4020 | 4420 | 4620 | 4920 | 4620 | 4720 | 5820 | 6020 |
| | 4020 | 4420 | 4620 | 4920 | 4520 | 4920 | 5920 | 6020 |
| | 4020 | 4420 | 4820 | 5020 | 4620 | 4620 | 5920 | 6020 |
| | 3820 | 4420 | 4920 | 5120 | 4920 | 4420 | 5920 | 6020 |
| | 3620 | 4220 | 4920 | 5120 | 5120 | 4420 | 5720 | 6020 |
| | 3220 | 4420 | 4720 | 5020 | 5120 | 4920 | 5420 | 6020 |
| | 2720 | 3920 | 4620 | 5020 | 5120 | 5020 | 5220 | 5720 |
| | 2220 | 3620 | 4420 | 4920 | 5120 | 5320 | 5420 | 5220 |
| | 1120 | 3420 | 3920 | 4920 | 5220 | 5220 | 5220 | 5220 |
| | 1820 | 2920 | 3420 | 4920 | 4420 | 3920 | 4420 | 3520 |
| | 3220 | 3420 | 3920 | 4420 | 4420 | 4420 | 3420 | 1620 |
| | 3920 | 3420 | 3420 | 2920 | 2920 | 4220 | 2920 | 920 |
| | 3420 | 3720 | 2920 | 1920 | 3420 | 3420 | 3420 | 1920 |
| | 2920 | 3720 | 3420 | 2920 | 1920 | 920 | 2920 | 1920 |
| | 2620 | 3420 | 3920 | 3420 | 2420 | 920 | 1920 | 1920 |
| | 2420 | 2920 | 3420 | 3920 | 2420 | 1420 | 420 | 920 |
| | 1920 | 2620 | 2920 | 3420 | 2920 | 2420 | 920 | 920 |
| Effect | 31·2 | 32·9 | 19·6 | 36·9 | 22·3 | 16·6 | 14·2 | 10·5 |

Effect of zones from 5·318 miles to 37·606 miles = 184·2

$$\text{Attraction} = 184·2 \times 0·000035 = 0·0064$$

The method of grouping blocks in order of height has been used up to a radius of 5.318 miles; beyond this, formula (2) has been employed, and the height of each block separately taken into account.

Up to 5.318 miles the calculation in *Vol. V. Op. G. T. S.* gives as the correction to the vibration number

$$8.6010,$$

which is equivalent to a correction of 0.1956 to the value of g .

The attraction of a disc of this radius and 6920 feet high is 0.2129 ; my computation of the defect due to inequalities yields 0.0184 and hence the attraction of the actual masses within a radius of 5.318 miles is

$$0.2129 - 0.0184 = 0.1945$$

As has already been explained, the effect of all levelling processes implied in the employment of mean heights, is to increase the attraction of the masses, the fact therefore that the new result is slightly less than the old one is favourable to the new method.

Between the radii of 5.318 and 37.606 miles the new computation gives as the defect due to inequalities

$$0.0064$$

The attraction of a zone bounded by cylinders of the above radii and 6920 feet high is, by formula (2),

$$0.0256$$

Hence the attraction of the actual masses is

$$0.0256 - 0.0064 = 0.0192$$

Col. Herschel's computation for the same zone gives in terms of N

$$0.8450$$

and this when converted into terms of the acceleration in centimeters is also

$$0.0192$$

Madras and Colaba.

No orographical corrections have been applied at Madras and Colaba. It might be thought that some allowance should be made for the presence of the sea; but, as has been remarked already, the present object is to reduce to sea level, so as to obtain numbers which may be compared with the computed values of γ_0 , and just as a uniform density has been assigned to all masses lying above sea level, so we must for the present refrain from differentiating between the substances which lie below it.

Orographical Correction at Dehra Dun.

In *Volume V. Op. G. T. S.* p. [177] the effect of the inequalities of the surface on the pendulum station at Dehra Dún is computed. The effect on the vibration number, of the zones up to a radius of 30 miles, is found to be

$$3.305$$

Which corresponds to a difference of

$$0.0752 \text{ in } g.$$

The attraction of a disc 2240 feet high and 30 miles in radius is

$$0.0780$$

So that the orographical correction within a radius of 30 miles is

$$0.0028$$

The total effect of all the zones up to an indefinitely great distance is found to be

$$3.18$$

This corresponds to ...

$$0.0724$$

The attraction of an infinite disc 2240 feet thick is

$$0.079$$

The difference is ...

$$0.0066$$

Thus the attraction of the zones outside a radius of 30 miles is

$$0.0066 - 0.0028 = 0.0038$$

It appears that all the particulars of Basevi's estimation of the heights of the compartments were not recoverable and as a check I have estimated the masses outside the 30-mile radius anew, as follows:—

| Azimuth (from south by west) | | Mean height | |
|---------------------------------|-----|-------------|----------|
| 0° to 120° | ... | ... | 900 feet |
| 120 „ 180 | ... | ... | 5000 „ |
| 180 „ 250 | ... | ... | 9000 „ |
| 250 „ 270 | ... | ... | 5000 „ |
| 270 „ 315 | ... | ... | 4000 „ |
| 315 „ 360 | ... | ... | 900 „ |

The orographical correction due to the difference between these masses and the infinite plain through the station outside the 30-mile radius is

$$0\cdot0013$$

So that the total orographical correction becomes

$$0\cdot0028 + 0\cdot0013 \\ = 0\cdot0041$$

which is in good agreement with Basevi's result.

In Table XII the observed values of g , the reductions to sea level, the theoretical values of γ_0 and the differences are exhibited.

Table XII. Synopsis of Results.

| Station | Latitude | Height | Observed g | $g \frac{2h}{R}$ | $g \frac{3}{4} \frac{h}{R}$ | O | Value at sea level g_0'' | γ_0 | $g_0'' - \gamma_0$ |
|--------------------------|----------|-----------|-----------------|------------------|-----------------------------|--------|----------------------------------|------------|--------------------|
| Dehra Dún ... | 30 19 | 2239 feet | 979·063 | +0·210 | -0·079 | +0·004 | 979·198 | 979·324 | -0·126 |
| Madras ... | 13 4 | 20 | 978·279 | +0·002 | -0·001 | 0 | 978·280 | 978·266 | +0·014 |
| Colaba ... | 18 54 | 34 | 978·631 | +0·003 | -0·001 | 0 | 978·633 | 978·545 | +0·088 |
| Mussooree (Dunseverick) | 30 27 | 7129 | 978·776 | +0·668 | -0·251 | +0·026 | 979·219 | 979·334 | -0·115 |
| Mussooree (Camel's Back) | 30 28 | 6924 | 978·793 | +0·649 | -0·243 | +0·026 | 979·225 | 979·335 | -0·110 |

CHAPTER III.

The Operations in the year 1904-05.

The locale of operations during this field season lay along the chain of triangles known as the Calcutta Meridional Series.

This line was selected by Colonel Burrard, Superintendent of Trigonometrical Surveys, for several reasons. It crosses the subterranean chain of excessive density, the existence of which was pointed out by him in professional paper No. 5: latitude observations recently made at stations of this series had shewn that the local deflection of the plumb-line must be largely influenced by invisible causes: the series runs right up to the foot of the Himalayas and meets them at a point whence the roads to Darjeeling and along the Nepal frontier afford unusual facilities for reaching points of considerable altitude: and, lastly, this part of the country was comparatively free from plague which was very bad in the United Provinces and in the Punjab.

As no houses were to be found in the neighbourhood of several of the stations which were selected, some portable arrangement had to be considered. It was thought that a tent of good quality would probably answer, and a large single poled tent, divided into two rooms by a curtain, was accordingly purchased. Inside one of the rooms an inner roof, consisting of ruberoid laid on a bamboo frame-work, was provided. An inspection of the results will shew that the protection from the sun's radiation was not sufficient, and that the temperature was far from steady.

During the summer of 1904 a new pendulum room had been prepared at Dehra Dún in the building which contains the great Photoheliograph. The new room was much superior to that in which the observations of January and June 1904 had been made, particularly as regards the temperature conditions.

The new station is due east of the old one and 590 feet distant from it. The floor of the new room is 2ft. higher than that of the old one.

Sets of observations were made in the new room and in the tent, or field station, both before proceeding to the field and after returning from it.

A difficult question has been how to deal with the observations taken in an unsteady temperature.

In Dehra Dún the mean hourly variations in the tent for each day and night were in degrees centigrade:—

| | Night | Day |
|-------------|-------|--------|
| in November | — ·05 | + 1·03 |
| | — ·14 | + 0·60 |
| <hr/> | | |
| and in May | — ·21 | + ·45 |
| | — ·27 | + ·76 |
| | — ·19 | + ·57 |

In the case of observations made in a room where the temperature varies but little, and that slowly, so long as the room is kept closed, and only commences to change when the observations begin, on account of the opening of the door, and of the presence of the observer and the necessary lamps, a correction of the form $K \frac{d\theta}{dt}$ is probably capable of expressing the difference between the temperature of the pendulum and that indicated by the thermometers. But when the principal cause of the change of temperature is the sun and the weather, it does not seem probable that such an expression, which only takes into account variations in the temperature over a short period, will be adequate. The difference of temperature must be a function not only of the rate of increase of temperature but also of the time that has elapsed since the rise began, and of the conditions preceding the rise. It seems impossible in the absence of data respecting those conditions to arrive at any satisfactory estimate of the difference in question, and I have thought it best, in the case of the tent stations, to apply no correction for lag, and to determine g by comparing the observed time of vibration with that obtained in the tent at Dehra Dún, trusting to the similarity of the conditions to eliminate the errors due to wrongly estimated temperatures.

At several of the stations houses more or less suitable were available and at two of those where there were no houses, huts of bamboo mats plastered with mud were made. In the latter and in the less suitable of the former the conditions did not correspond exactly either to those of the tent or of the room at Dehra Dún, and g has been deduced firstly by comparing the observed time of vibration with that obtained at the Dehra Dún field station applying no lag correction, and, secondly, by comparing with that obtained in the pendulum room applying a lag correction; finally the mean of the two results has been taken.

In this way the magnitude of the uncertainty in the deduced g , to which the unsteady temperature gives rise, is exhibited.

At stations where houses not greatly inferior to the pendulum room were available, comparison has only been made with the observations made in the latter, the lag correction being applied as usual.

Throughout this season the time observations were made by Extra Assistant Superintendent Hanuman Prasad with Transit Instrument No. 2 by Troughton & Simms. The half-seconds pendulum clock S.R. 238 was used to actuate both the chronograph and the flash-box. The chronograph was the same one as had been used in the former season, namely the heavy drum chronograph made by Messrs. Warner and Swasey.

The pendulum stand was always erected on a brick pillar specially built for it, and at the stations where the tent was used small blocks of bricks in cement were made for the feet of the clock stand.

The same thermometers were used as during the former season, *viz*: Nos. 105368 and 105369 by Negretti and Zambra.

The pressure of the air was measured by a mercurial barometer on Fortin's principle; an aneroid barometer was also carried and read, chiefly as a safeguard against accidental gross errors in reading the mercurial one.

The humidity was determined by readings of wet and dry bulb thermometers.

At the end of January Professor Dr. O. Hecker of the Prussian Geodetic Institute joined me while I was at Jalpaiguri. Dr. Hecker had been engaged upon an important series of observations with barometers and hypsometers, made during voyages to Australia, Japan and elsewhere, for determining the force of gravity in mid-ocean, but he was also equipped with a set of pendulums and the necessary accessories, and the excellent suggestion was made by Professor Helmert that he should visit India on his way home from Japan, join the pendulum party wherever it might be, and swing his pendulums alongside of ours.

I selected Jalpaiguri as the most convenient place for the simultaneous observations, and was so fortunate as to secure as an observatory a good room in which the temperature was satisfactorily steady.

By means of these observations an independent value of g at Dehra Dún is obtained. For my work gives the difference Dehra Dún—Jalpaiguri and Dr. Hecker's gives Potsdam—Jalpaiguri, whence Potsdam—Dehra Dún becomes known. The absolute value of g at Potsdam, which has recently been determined with extreme care, is 981.274. The value which has been adopted for Kew, namely 981.200 is based on the Potsdam determination, and rests on the measure of the difference made by Mr. G. R. Putnam in 1900. We have an indirect check on Mr. Putnam's result through the chain Kew—Dehra Dún—Jalpaiguri—Potsdam. The details of Dr. Hecker's observations are given at the end of this Chapter.

THE STATIONS.

Dehra Dun.

The new pendulum room is situated in the observatory which contains the large photo-heliograph.

The new pendulum pillar is due east of Basevi's station, 590 feet from it and 2 feet higher.

The co-ordinates of new pendulum station are:—

| | | | | | |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 19 | 29 |
| Longitude | ... | ... | 78 | 3 | 22 |
| Height above mean sea level | ... | | | | 2241 feet |

The Dehra Dún field station is 62 feet north and 5 feet east of the pillar in the pendulum room, and the ground on which it stands is 1 foot lower than the floor of the room.

In November 1904, before starting for the field, observations were taken both in the room and at the field station.

In the room the flexure correction was determined five times.

| 8th November | 13th November |
|-----------------------|-----------------------|
| 46.7×10^{-7} | 41.5×10^{-7} |
| 42.4 | 45.8 |
| | 44.6 |
| Adopted Correction | -44×10^{-7} |

At the field station it was determined four times.

| 21st November | 24th November |
|-----------------------|-----------------------|
| 41.3×10^{-7} | 40.7×10^{-7} |
| 41.2 | 41.7 |
| Adopted Correction | -41×10^{-7} |

Cuttack G. T. S.

No. XXXV of the East Coast Series.

The pendulum station was in a small house, which had originally been erected as a cholera hospital but had never been used. The pillar was about 480 feet north and 23 feet west of the Cuttack G. T. S.

The co-ordinates of the pendulum pillar are :—

| | | | | | |
|-----------|-----|-----|---------|----|---|
| Latitude | ... | ... | 20 | 29 | 5 |
| Longitude | ... | ... | 85 | 52 | 1 |
| Height | ... | ... | 92 feet | | |

The temperature conditions were not good, chiefly owing to there being a space between the walls and the roof for ventilation. The results have been taken out both with and without a lag correction, for comparison with the two Dehra Dún values.

The flexure correction was determined six times.

| December 12th | December 16th | December 17th |
|-----------------------|-----------------------|-----------------------|
| 61.4×10^{-7} | 52.4×10^{-7} | 51.4×10^{-7} |
| 60.7 | 51.4 | 52.5 |

There is large change between the results of the 12th and 16th due undoubtedly to the gradual hardening of the cement in the pillar, which at this station it had not been possible to build beforehand. For the observations between the 12th and 16th a flexure correction of -56×10^{-7} has been adopted, and for those on the 16th and 17th one of -52×10^{-7} .

Chatra G. T. S.

No. XVIII of the Calcutta Meridional Series.

The station of the principal triangulation has been completely washed away by the Bhairab river. But its position was fairly well known to the villagers and I do not think there can be an error of more than 50 yards in the point which they showed me. The pendulum pillar was 300 yards south and 550 yards west of the most probable position of the old Tower station. The country is perfectly flat for miles in every direction and it has been assumed that the ground level at the new station is the same as it was at the old one.

The co-ordinates of the pendulum station are :—

| | | | | | |
|-----------------------------|-----|-----|---------|----|----|
| Latitude | ... | ... | 24 | 12 | 40 |
| Longitude | ... | ... | 88 | 23 | 27 |
| Height above mean sea level | ... | ... | 64 feet | | |

The tent formed the observatory.

The flexure correction was determined five times as follows :—

| December 30th | January 1st | January 3rd |
|-----------------------|-----------------------|-----------------------|
| 63.1×10^{-7} | 58.7×10^{-7} | 59.9×10^{-7} |
| 63.6 | | 57.4 |

The following values have been adopted :—

| | | |
|-------------|---|----------------------|
| December 30 | } | -61×10^{-7} |
| 31 | | |
| December 31 | } | -61×10^{-7} |
| January 1 | | |
| January 1 | } | -59×10^{-7} |
| 2 | | |

Kisnapur G. T. S.

No. XXIX of the Calcutta Meridional Series.

The pendulum pillar was situated 851 feet south and 83 feet east of the G. T. station and on ground 4 feet lower than that surrounding the base of the old Tower. The latter was not entire and the upper mark-stone could not be found, so there is a little uncertainty as to the height, for the ground is uneven, but there cannot be an error of more than 3 feet.

The co-ordinates of the pendulum station are :—

| | | ° | ' | " |
|-----------------------------|-----|----------|----|----|
| Latitude | ... | 25 | 2 | 26 |
| Longitude | ... | 88 | 28 | 29 |
| Height above mean sea level | ... | 113 feet | | |

The tent formed the observatory.

The flexure correction was determined seven times :—

| January 17 | January 19 | January 21 | January 23 |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 64.6×10^{-7} | 57.4×10^{-7} | 56.5×10^{-7} | 56.7×10^{-7} |
| 65.4 | 55.9 | 54.4 | |

The following values of the correction have been adopted :—

| | | |
|---------|-------|----------------------|
| January | 17—18 | -61×10^{-7} |
| " | 18—19 | -61 " |
| " | 19—20 | -57 " |
| " | 21—22 | -56 " |
| " | 22—23 | -57 " |

There was a good deal of cloud and rain at this station and star observations were only obtained on the 17th, 20th, 21st and 23rd. The five sets of observations therefore only yield two independent results, namely, (1) those from the evening of 17th to the morning of the 20th, and (2) those from the evening of the 21st to the morning of the 23rd.

Jalpaiguri.

The pendulum station was situated in a room of a building belonging to the District Treasury. The pillar was 123 feet west and 63 feet north of the station of the triangulation called Jalpaiguri s. The latter is on the roof of another of the Treasury buildings.

The co-ordinates of the pendulum station are :—

| | | ° | ' | " |
|-----------------------------|----------|----|----|----|
| Latitude | ... | 26 | 31 | 16 |
| Longitude | ... | 88 | 44 | 13 |
| Height above mean sea level | 268 feet | | | |

One of the lines of principal levelling runs up the railway which passes through Jalpaiguri, and there is a bench-mark at the station. A subsidiary line of levels was run from this bench-mark to the pendulum room.

The floor was of thick concrete and isolated pillars were not provided.

Dr. Hecker's apparatus and mine were set up at opposite ends of the room, the clock being between them. The same clock, namely S.R. 238, was used for timing both sets of pendulums.

The pillars for both instruments had to be erected hurriedly after the arrival of the observers, and in consequence the cement was not hard when work began. The result of this is clearly seen in the flexure correction.

I determined this correction eight times with the following results:—

| January 31st 6 P.M. | February 1st 6 P.M. | February 2nd 4 P.M. | February 3rd 6 P.M. |
|--|--|--|--|
| $\begin{matrix} s \\ 54.2 \times 10^{-7} \\ 52.1 \end{matrix}$ | $\begin{matrix} s \\ 43.6 \times 10^{-7} \\ 44.6 \end{matrix}$ | $\begin{matrix} s \\ 44.1 \times 10^{-7} \\ 44.5 \end{matrix}$ | $\begin{matrix} s \\ 42.8 \times 10^{-7} \\ 40.3 \end{matrix}$ |
| 53.2×10^{-7} | 44.1×10^{-7} | 44.3×10^{-7} | 41.6×10^{-7} |

By plotting these values as the ordinates of points, of which the abscissæ were intervals of time, and drawing a smooth curve through them the following values of the flexure correction were obtained:—

| | |
|------------------|----------------------|
| January 31 Night | -50×10^{-7} |
| February 1 Day | -46 " |
| " 1 Night | -44 " |
| " 2 Day | -44 " |
| " 2 Night | -43 " |
| " 3 Day | -42 " |

The temperature conditions were good and g has been determined by comparison with the observations in the pendulum room at Dehra Dûn, applying the usual lag correction.

Kesarbari G. T. S.

No. XLIII of the Calcutta Meridional Series.

The pendulum pillar was situated 194 feet east and 24 feet south of the G. T. S. and on ground 5 feet lower than that at the base of the Tower. The upper mark-stone of the latter was missing and there is therefore an uncertainty of about 2 feet in the height.

The co-ordinates of the pendulum station are:—

| | | | | | |
|-----------------------------|-----|-----|-----|------|----|
| Latitude | ... | ... | 26 | 7 | 41 |
| Longitude | ... | ... | 88 | 31 | 26 |
| Height above mean sea level | ... | ... | 204 | feet | |

The tent formed the observatory, but as an additional protection against variations of temperature a hut of thatch and matting was erected inside the tent.

Bad weather was encountered here; star observations were only obtained on February 14th and 18th. The sky was overcast from 11 p. m. on the 14th until 10 a. m. on the 18th. The four sets of observations only yield one value of the time of vibration.

The flexure correction was determined six times:—

| | | |
|--|--|--|
| February 14th | February 15th | February 18th |
| $\begin{matrix} s \\ 73.4 \times 10^{-7} \\ 71.2 \end{matrix}$ | $\begin{matrix} s \\ 69.4 \times 10^{-7} \\ 72.9 \end{matrix}$ | $\begin{matrix} s \\ 68.4 \times 10^{-7} \\ 69.8 \end{matrix}$ |
| Adopted correction | -71×10^{-7} | |

Ramchandpur.

The pendulum station was situated 3390 feet north and 2355 feet east of Rámchandpur G. T. S. No. XXXVII of the Calcutta Meridional Series, and on ground 14 feet higher than that at the base of the Tower.

The co-ordinates of the pendulum station are :—

| | | | | | |
|-----------------------------|-----|-----|----|----|----------|
| | | | ° | ' | " |
| Latitude | ... | ... | 25 | 40 | 57 |
| Longitude | ... | ... | 88 | 32 | 58 |
| Height above mean sea level | ... | | | | 132 feet |

At this station the tent was not used but a room was constructed of bamboos, thatch and mud plaster under a large mango tree. It was to obtain the advantage of the shade of this tree that a point so distant from the Tower was selected.

The flexure correction was determined seven times :—

| 25th February | 26th February | 28th February |
|-----------------------|-----------------------|-----------------------|
| 66.0×10^{-7} | 69.4×10^{-7} | 64.3×10^{-7} |
| 69.6 | | 63.2 |
| 71.2 | | |
| 67.6 | | |

Adopted values of the correction

| | |
|------------------|----------------------|
| 25—26th February | -69×10^{-7} |
| 26—27 | -68 |
| 27—28 | -66 |

Siliguri.

A bungalow belonging to the Jalpaiguri District Board was lent me for the pendulum observations. It is situated about $1\frac{1}{2}$ miles W. S. W. of the Siliguri railway station. There is a bench-mark of the principal levelling on the step of the bungalow and a secondary triangulation station about 200 yards further south, at the side of the main road to Titalia.

The co-ordinates of the pendulum station are :—

| | | | | | |
|-----------------------------|-----|-----|----|----|----------|
| | | | ° | ' | " |
| Latitude | ... | ... | 26 | 41 | 47 |
| Longitude | ... | ... | 88 | 24 | 50 |
| Height above mean sea level | ... | | | | 387 feet |

The floors of the two main rooms of the bungalow were of wood, but that of the bath-room of the larger of the two was of concrete. I therefore built the pendulum pillar in the bath-room and observed through the door. The clock also was erected in the bath-room.

The roof of this room was of iron and I had a layer of earth laid upon it, even so however the temperature conditions were not good and g has been determined by both of the methods described on p. 71.

The observations were greatly delayed by bad weather. I arrived on the 8th March but could get no star observations till the 12th; the 14th and 15th were also cloudy and the closing observations were not obtained until the 16th.

Flexure was observed several times before work began, but the observations which have been utilised in deducing the correction were only 4 in number, *viz.*,

| 13th February | 16th February |
|-----------------------|-----------------------|
| 64.4×10^{-7} | 63.4×10^{-7} |
| 64.9 | 64.5 |
| Adopted Correction | $- 64 \times 10^{-7}$ |

Darjeeling.

The pendulum pillar was erected in a room with a northerly aspect on the ground floor of the Bengal Secretariat office.

The floor of the room was found by vertical angles and levelling to be 202 feet below the station of the triangulation on Observatory Hill, and the pendulum pillar was approximately 400 feet south and 500 feet west of that station.

The co-ordinates of the pendulum pillar are therefore :—

| | ° | ' | " |
|---------------------------------|-----------|----|----|
| Latitude ... | 27 | 2 | 47 |
| Longitude ... | 88 | 16 | 8 |
| Height above mean sea level ... | 6966 feet | | |

The room was a very suitable one, the temperature conditions were satisfactory and the clock and pendulum pillars free from liability to tremors.

The flexure correction was determined five times.

| 20th March | 23rd March |
|-----------------------|-----------------------|
| 57.4×10^{-7} | 56.0×10^{-7} |
| 58.2 | 54.5 |
| 60.7 | |
| Adopted Correction | $- 57 \times 10^{-7}$ |

Kurseong.

The pendulum pillar was built in the bath-room of the north room of the Dāk or Inspection bungalow. This bungalow is situated close to the railway on its eastern side and about a quarter of a mile above the railway station.

The level of the floor was determined by spirit-levelling from the railway station. A traverse was run to a station of the secondary triangulation in order to obtain the latitude and longitude.

The co-ordinates of the pendulum station are :—

| | ° | ' | " |
|---------------------------------|-----------|----|----|
| Latitude ... | 26 | 52 | 51 |
| Longitude ... | 88 | 16 | 45 |
| Height above mean sea level ... | 4913 feet | | |

The floor of the bath-room was of cement and of good quality but that of the room was of planks and very unsteady. The clock was fixed to the wall of the room.

Flexure was observed seven times.

| 26th March | 27th March | 30th March | 1st April |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 35.7×10^{-7} | 35.3×10^{-7} | 34.7×10^{-7} | 35.8×10^{-7} |
| 35.4 | ... | 34.0 | 35.3 |
| Adopted Correction | | $- 35 \times 10^{-7}$ | |

Sandakphu.

The hill of this name is a peak of a remarkable spur which extends from Kinchinjunga to the plains. The Nepal frontier runs along this ridge and a road has been constructed almost parallel to the frontier on the British side of it. There are rest-houses at intervals along this road and that at Sandakphu was kindly placed at my disposal by the Deputy Commissioner of Darjeeling.

The floors of the rest-house are planked but I was able to erect the pendulum pillar in the bath-room in the same way as I had done at Siliguri and Kurseong. The clock was fixed to the wall of the room.

There is a station of the triangulation on the peak of Sandakphu and the pendulum pillar was 560 feet north and 1150 feet east of it.

The elevation of the floor of the room was 163 feet less than that of the triangulation station.

The co-ordinates of the pendulum station are :—

| | | | | | |
|-----------------------------|-----|-----|------------|---|----|
| Latitude | ... | ... | 27 | 6 | 6 |
| Longitude | ... | ... | 88 | 0 | 15 |
| Height above mean sea level | ... | ... | 11766 feet | | |

The observations at this station were carried out under somewhat adverse circumstances. The spring had been an unusually severe one and the snow-fall had been heavy, so that the road was only just open at the time when the party started from Kurseong, although the date of starting had been put as late as possible. The march was accomplished without serious difficulty, but after the instruments had been erected and during the progress of the observations very bad weather was met with. No star observations were obtained on the 9th of April which was the first night: on the 10th there were clouds till 10 p.m. then however it cleared for two hours; a good time determination was made, and I was enabled to begin observing the pendulums. The next evening it was clear from 7 p.m. till about 10 p.m. and good observations were obtained. On the 12th there was a severe snowstorm with high wind in the afternoon and the sky remained cloudy all night though hope of success was not abandoned till 2 a.m. On the 13th there was a heavy fall of snow in the afternoon followed by a perfect hurricane of wind which blew all night: the sky however was clear from about 8 p.m. and Babu Hanuman Prasad succeeded in getting a sufficient number of stars, though in the face of great difficulties, for the wind was sending the powdery snow whirling through the meridional slit, and there seemed to be imminent danger of the whole tent being blown away; it was moreover intensely cold. The advantage of having a large and stable transit-instrument and a good drum chronograph was clearly shewn, for no trustworthy observations by the eye and ear method, or with a light instrument, would have been possible on any of the nights of our stay.

The room in the rest-house was good and it was possible to keep the temperature fairly steady.

The flexure correction was determined six times.

| | 10th April | 12th April | 13th April |
|--------------------|---|---|---------------------------------------|
| | ^s 47.7×10^{-7} | | ^s 46.3×10^{-7} |
| | 50.5 | ^s ... 45.6×10^{-7} | 47.0 |
| | 47.4 | ... | ... |
| Mean | 48.5 | 45.6 | 46.7 |
| Adopted Correction | <hr/> ^s $- 47 \times 10^{-7}$ <hr/> | | |

Dehra Dun.

On returning to Dehra Dún observations were again made both at the field station and in the pendulum room.

At the field station flexure was observed six times.

| | 9th May | 10th May | 16th May |
|--------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| | ^s 35.4×10^{-7} | | ^s 36.2×10^{-7} |
| | 39.5 | ^s 36.1×10^{-7} | 36.8 |
| | 37.5 | | |
| Adopted Correction | ^s $- 37 \times 10^{-7}$ | | |

In the room it was observed four times.

| | 17th May | 21st May |
|--------------------|---------------------------------------|---------------------------------------|
| | ^s 41.5×10^{-7} | ^s 42.7×10^{-7} |
| | 40.2 | 42.5 |
| Adopted Correction | ^s $- 42 \times 10^{-7}$ | |

Table I. Details of the Observations.

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration |
|----------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|------------------------------------|--------------------------|-----|-------------|-----|----------------|---------|---------------------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | |
| Dehra Dun—(Pendulum room). | | | | | | | | | | | | | | | |
| 8-9 November, 1904. | | | | | | | | | | | | | | | |
| 137 | 2 26 | 34.238 | — 0.31 | 13 | 20.34 | +0.09 | 0.850 | 0.5074100 | + 18 | —5 | — 997 | + 2 | — 505 | —44 | 0.5072569 |
| 139 | 3 25 | 34.681 | 0.31 | 12 | 20.56 | 0.09 | 0.849 | 0.5073141 | 18 | 4 | 1007 | 2 | 514 | 44 | 0.5071592 |
| 138 | 4 29 | 33.182 | 0.31 | 13 | 20.61 | 0.09 | 0.850 | 0.5076495 | 18 | 5 | 1010 | 2 | 486 | 44 | 0.5074970 |
| 140 | 5 26 | 35.040 | 0.31 | 15 | 20.65 | 0.09 | 0.850 | 0.5072380 | 18 | 6 | 1012 | 2 | 515 | 44 | 0.5070823 |
| | | | | | | | | | | | | | Mean | ... | 0.5072489 |
| 137 | 14 39 | 34.218 | — 0.31 | 13 | 20.28 | +0.11 | 0.851 | 0.5074145 | + 18 | —5 | — 994 | + 3 | — 505 | —44 | 0.5072618 |
| 139 | 15 37 | 34.659 | 0.31 | 12 | 20.40 | 0.11 | 0.850 | 0.5073187 | 18 | 4 | 1000 | 3 | 515 | 44 | 0.5071645 |
| 138 | 16 42 | 33.156 | 0.31 | 14 | 20.52 | 0.11 | 0.849 | 0.5076556 | 18 | 5 | 1005 | 3 | 486 | 44 | 0.5075037 |
| 140 | 17 37 | 35.034 | 0.31 | 13 | 20.58 | 0.11 | 0.849 | 0.5072395 | 18 | 5 | 1008 | 3 | 514 | 44 | 0.5070845 |
| | | | | | | | | | | | | | Mean | ... | 0.5072536 |
| | | | | | | | | Time of Vibration of Mean Pendulum | ... | | | | | | 0.5072513 |
| 9-10 November, 1904. | | | | | | | | | | | | | | | |
| 140 | 2 32 | 35.042 | — 0.45 | 13 | 20.52 | —0.04 | 0.852 | 0.5072376 | + 26 | —5 | —1005 | — 1 | — 516 | —44 | 0.5070831 |
| 138 | 3 35 | 33.169 | 0.45 | 13 | 20.59 | 0.04 | 0.853 | 0.5076525 | 26 | 5 | 1009 | 1 | 488 | 44 | 0.5075004 |
| 139 | 4 32 | 34.676 | 0.45 | 14 | 20.48 | 0.04 | 0.853 | 0.5073151 | 26 | 5 | 1004 | 1 | 517 | 44 | 0.5071606 |
| 137 | 5 30 | 34.229 | 0.45 | 13 | 20.49 | 0.04 | 0.853 | 0.5074120 | 26 | 5 | 1004 | 1 | 507 | 44 | 0.5072585 |
| | | | | | | | | | | | | | Mean | ... | 0.5072506 |
| 140 | 14 50 | 35.030 | — 0.45 | 14 | 20.18 | +0.13 | 0.853 | 0.5072400 | + 26 | —5 | — 989 | + 3 | — 517 | —44 | 0.5070874 |
| 138 | 15 48 | 33.159 | 0.45 | 14 | 20.34 | 0.13 | 0.853 | 0.5076549 | 26 | 5 | 997 | 3 | 488 | 44 | 0.5075044 |
| 139 | 16 45 | 34.658 | 0.45 | 13 | 20.45 | 0.13 | 0.851 | 0.5073188 | 26 | 5 | 1002 | 3 | 516 | 44 | 0.5071650 |
| 137 | 17 44 | 34.208 | 0.45 | 15 | 20.55 | 0.13 | 0.849 | 0.5074167 | 26 | 6 | 1007 | 3 | 504 | 44 | 0.5072635 |
| | | | | | | | | | | | | | Mean | ... | 0.5072551 |
| | | | | | | | | Time of Vibration of Mean Pendulum | ... | | | | | | 0.5072529 |
| 10-11 November, 1904. | | | | | | | | | | | | | | | |
| 139 | 2 47 | 34.679 | — 0.61 | 14 | 20.56 | —0.01 | 0.850 | 0.5073145 | + 36 | —5 | —1007 | 0 | — 515 | —44 | 0.5071610 |
| 137 | 3 44 | 34.239 | 0.61 | 14 | 20.57 | 0.01 | 0.852 | 0.5074098 | 36 | 5 | 1008 | 0 | 506 | 44 | 0.5072571 |
| 140 | 4 44 | 35.043 | 0.61 | 13 | 20.54 | 0.01 | 0.851 | 0.5072372 | 36 | 5 | 1006 | 0 | 516 | 44 | 0.5070837 |
| 138 | 5 43 | 33.174 | 0.61 | 14 | 20.58 | 0.01 | 0.850 | 0.5076515 | 36 | 5 | 1008 | 0 | 486 | 44 | 0.5075008 |
| | | | | | | | | | | | | | Mean | ... | 0.5072507 |
| 139 | 14 52 | 34.679 | — 0.61 | 13 | 20.29 | +0.12 | 0.851 | 0.5073145 | + 36 | —5 | — 994 | + 3 | — 516 | —44 | 0.5071625 |
| 137 | 15 49 | 34.227 | 0.61 | 15 | 20.46 | 0.12 | 0.850 | 0.5074126 | 36 | 6 | 1003 | 3 | 505 | 44 | 0.5072607 |
| 140 | 16 48 | 35.033 | 0.61 | 14 | 20.55 | 0.12 | 0.849 | 0.5072396 | 36 | 5 | 1007 | 3 | 514 | 44 | 0.5070865 |
| 138 | 17 44 | 33.163 | 0.61 | 14 | 20.64 | 0.12 | 0.848 | 0.5076538 | 36 | 5 | 1011 | 3 | 485 | 44 | 0.5075032 |
| | | | | | | | | | | | | | Mean | ... | 0.5072532 |
| | | | | | | | | Time of Vibration of Mean Pendulum | ... | | | | | | 0.5072519 |
| 11-12 November, 1904. | | | | | | | | | | | | | | | |
| 138 | 3 12 | 33.168 | — 0.67 | 14 | 20.55 | +0.06 | 0.851 | 0.5076529 | + 39 | —5 | —1007 | + 2 | — 487 | —44 | 0.5075027 |
| 140 | 4 8 | 35.029 | 0.67 | 14 | 20.51 | 0.06 | 0.851 | 0.5072402 | 39 | 5 | 1005 | 2 | 516 | 44 | 0.5070873 |
| 137 | 5 8 | 34.220 | 0.67 | 14 | 20.61 | 0.06 | 0.850 | 0.5074140 | 39 | 5 | 1010 | 2 | 505 | 44 | 0.5072617 |
| 139 | 6 3 | 34.665 | 0.67 | 14 | 20.67 | 0.06 | 0.850 | 0.5073175 | 39 | 5 | 1013 | 2 | 515 | 44 | 0.5071639 |
| | | | | | | | | | | | | | Mean | ... | 0.5072539 |
| 138 | 15 15 | 33.179 | — 0.67 | 14 | 20.33 | +0.02 | 0.855 | 0.5076501 | + 39 | —5 | — 996 | + 1 | — 489 | —44 | 0.5075007 |
| 140 | 16 12 | 35.047 | 0.67 | 14 | 20.40 | 0.02 | 0.854 | 0.5072366 | 39 | 5 | 1000 | 1 | 518 | 44 | 0.5070839 |
| 137 | 17 13 | 34.237 | 0.67 | 14 | 20.40 | 0.02 | 0.854 | 0.5074103 | 39 | 5 | 1000 | 1 | 507 | 44 | 0.5072587 |
| 139 | 18 12 | 34.680 | 0.67 | 14 | 20.40 | 0.02 | 0.851 | 0.5073142 | 39 | 5 | 1000 | 1 | 516 | 44 | 0.5071617 |
| | | | | | | | | | | | | | Mean | ... | 0.5072513 |
| | | | | | | | | Time of Vibration of Mean Pendulum | ... | | | | | | 0.5072526 |
| | | | | | | | | General Mean | ... | | | | | | 0.5072522 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|------|---------------------------|---------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| Dehra Dun—(Field Station, Tent). | | | | | | | | | | | | | | | | |
| 21-22 November, 1904. | | | | | | | | | | | | | | | | |
| 137 | 6 23 | 34°34.9 | — | 1°11 | 15 | 15°46 | —0°05 | 0.873 | 0.5073858 | + 65 | —6 | —758 | No lag correction applied | — 519 | —41 | 0.5072599 |
| 139 | 7 26 | 34°7.97 | | 1°11 | 16 | 15°54 | —0°05 | 0.872 | 0.5072892 | 65 | 7 | 761 | | — 528 | 41 | 0.5071620 |
| 138 | 8 27 | 33°28.4 | | 1°11 | 17 | 15°47 | —0°05 | 0.873 | 0.5076256 | 65 | 8 | 758 | | 499 | 41 | 0.5075015 |
| 140 | 9 26 | 35°16.5 | | 1°11 | 15 | 15°32 | —0°05 | 0.874 | 0.5072118 | 65 | 6 | 751 | | 530 | 41 | 0.5070855 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072522 |
| 137 | 18 32 | 34°37.0 | — | 1°11 | 15 | 15°75 | +1°03 | 0.861 | 0.5073812 | + 65 | —6 | —772 | No lag correction applied | — 511 | —41 | 0.5072547 |
| 139 | 19 29 | 34°7.97 | | 1°11 | 16 | 16°85 | 1°03 | 0.856 | 0.5072893 | 65 | 7 | 826 | | 519 | 41 | 0.5071565 |
| 138 | 20 27 | 33°26.4 | | 1°11 | 16 | 17°84 | 1°03 | 0.852 | 0.5076302 | 65 | 7 | 874 | | 487 | 41 | 0.5074958 |
| 140 | 21 26 | 35°11.1 | | 1°11 | 16 | 18°67 | 1°03 | 0.849 | 0.5072230 | 65 | 7 | 915 | | 514 | 41 | 0.5070818 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072472 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | 0.5072497 |
| 22-23 November, 1904. | | | | | | | | | | | | | | | | |
| 140 | 6 14 | 35°15.8 | — | 1°18 | 16 | 15°77 | —0°14 | 0.872 | 0.5072132 | + 69 | —7 | —773 | No lag correction applied | — 528 | —41 | 0.5070852 |
| 138 | 7 13 | 33°28.2 | | 1°18 | 14 | 15°73 | —0°14 | 0.872 | 0.5076261 | 69 | 5 | 771 | | 499 | 41 | 0.5075014 |
| 139 | 8 14 | 34°7.96 | | 1°18 | 14 | 15°58 | —0°14 | 0.872 | 0.5072896 | 69 | 5 | 763 | | 528 | 41 | 0.5071628 |
| 137 | 9 15 | 34°35.1 | | 1°18 | 14 | 15°36 | —0°14 | 0.872 | 0.5073855 | 69 | 5 | 753 | | 518 | 41 | 0.5072607 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072525 |
| 140 | 18 20 | 35°19.0 | — | 1°18 | 16 | 15°24 | +0°60 | 0.863 | 0.5072067 | + 69 | —7 | —747 | No lag correction applied | — 523 | —41 | 0.5070818 |
| 138 | 19 27 | 33°29.3 | | 1°18 | 15 | 16°09 | —0°60 | 0.859 | 0.5076235 | 69 | 6 | 788 | | 491 | 41 | 0.5074978 |
| 139 | 20 27 | 34°7.89 | | 1°18 | 15 | 16°63 | —0°60 | 0.857 | 0.5072912 | 69 | 6 | 815 | | 519 | 41 | 0.5071600 |
| 137 | 21 24 | 34°32.6 | | 1°18 | 15 | 17°08 | —0°60 | 0.856 | 0.5073908 | 69 | 6 | 837 | | 508 | 41 | 0.5072585 |
| | | | | | | | | | | | | | | Mean | ... | 0.5072495 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | 0.5072510 |
| General Mean | | | | | | | | | | | | | | | | 0.5072504 |
| Cuttack. | | | | | | | | | | | | | | | | |
| 12-13 December, 1904. | | | | | | | | | | | | | | | | |
| 137 | 3 27 | 33°31.4 | +13°40 | 16 | 23°10 | —0°42 | 0.914 | 0.5076187 | —787 | —7 | —1132 | — 11 | — 543 | —56 | 0.5073651 | |
| 139 | 4 23 | 33°7.45 | 13°40 | 16 | 22°80 | —0°42 | 0.917 | 0.5075200 | 787 | 7 | 1117 | 11 | 556 | 56 | 0.5072666 | |
| 138 | 5 21 | 32°32.6 | 13°40 | 17 | 22°32 | —0°42 | 0.921 | 0.5078553 | 787 | 7 | 1094 | 11 | 527 | 56 | 0.5076071 | |
| 140 | 6 15 | 34°10.2 | 13°40 | 17 | 21°95 | —0°42 | 0.921 | 0.5074401 | 787 | 8 | 1076 | 11 | 558 | 56 | 0.5071905 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073573 | |
| 137 | 15 33 | 33°36.0 | +13°40 | 17 | 22°12 | +0°76 | 0.914 | 0.5076080 | —787 | —8 | —1084 | + 19 | — 543 | —56 | 0.5073621 | |
| 139 | 16 32 | 33°7.69 | 13°40 | 16 | 22°90 | —0°76 | 0.911 | 0.5075146 | 787 | 7 | 1122 | 19 | 552 | 56 | 0.5072641 | |
| 138 | 17 30 | 32°33.2 | 13°40 | 17 | 23°80 | —0°76 | 0.906 | 0.5078536 | 787 | 8 | 1166 | 19 | 518 | 56 | 0.5076020 | |
| 140 | 18 28 | 34°07.5 | 13°40 | 17 | 24°25 | —0°76 | 0.907 | 0.5074459 | 787 | 8 | 1188 | 19 | 550 | 56 | 0.5071889 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073543 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | 0.5073558 |
| Do. not applying lag correction | | | | | | | | | | | | | | | | 0.5073554 |
| 13-14 December, 1904. | | | | | | | | | | | | | | | | |
| 140 | 3 39 | 34°07.4 | +14°04 | 16 | 22°07 | —0°42 | 0.916 | 0.5074463 | —824 | —7 | —1126 | — 11 | — 555 | —56 | 0.5071884 | |
| 138 | 4 39 | 32°32.1 | 14°04 | 17 | 22°57 | —0°42 | 0.920 | 0.5078565 | 824 | 8 | 1106 | 11 | 526 | 56 | 0.5076034 | |
| 139 | 5 35 | 33°7.53 | 14°04 | 15 | 22°14 | —0°42 | 0.922 | 0.5075181 | 824 | 6 | 1085 | 11 | 559 | 56 | 0.5072640 | |
| 137 | 6 34 | 33°34.4 | 14°04 | 16 | 21°78 | —0°42 | 0.923 | 0.5076117 | 824 | 7 | 1067 | 11 | 548 | 56 | 0.5073604 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073541 | |
| 140 | 15 45 | 34°12.9 | +14°04 | 16 | 21°67 | +0°54 | 0.916 | 0.5074341 | —824 | —7 | —1062 | + 13 | — 555 | —56 | 0.5071850 | |
| 138 | 16 40 | 32°33.2 | 14°04 | 17 | 22°30 | —0°54 | 0.914 | 0.5078538 | 824 | 8 | 1093 | 13 | 523 | 56 | 0.5076047 | |
| 139 | 17 37 | 33°7.43 | 14°04 | 15 | 22°82 | —0°54 | 0.912 | 0.5075202 | 824 | 6 | 1118 | 13 | 553 | 56 | 0.5072658 | |
| 137 | 18 34 | 33°31.5 | 14°04 | 17 | 23°20 | —0°54 | 0.910 | 0.5076185 | 824 | 8 | 1137 | 13 | 541 | 56 | 0.5073632 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073547 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | 0.5073544 |
| Do. not applying lag correction | | | | | | | | | | | | | | | | 0.5073543 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|---------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|------------------------------------|--------------------------|-----|-------------|------|----------------|---------|---------------------------|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 14-15 December, 1904. | | | | | | | | | | | | | | | | |
| 139 | 3 40 | 33' 731 | + 14' 16 | 17 | 22° 67 | - 0° 38 | 0·917 | 0·5075232 | - 831 | - 8 | - 1111 | - 10 | - 556 | - 56 | 0·5072660 | |
| 137 | 4 38 | 33' 318 | 14' 16 | 16 | 22° 26 | 0° 38 | 0·921 | 0·5076180 | 831 | 7 | 1091 | 10 | 547 | 56 | 0·5073638 | |
| 140 | 5 34 | 34' 086 | 14' 16 | 15 | 21° 90 | 0° 38 | 0·921 | 0·5074433 | 831 | 6 | 1073 | 10 | 558 | 56 | 0·5071899 | |
| 138 | 6 31 | 32' 329 | 14' 16 | 17 | 21° 59 | 0° 38 | 0·923 | 0·5078546 | 831 | 8 | 1058 | 10 | 528 | 56 | 0·5076055 | |
| | | | | | | | | | | | | | Mean | ... | 0·5073563 | |
| 139 | 15 42 | 33' 772 | + 14' 16 | 15 | 21° 33 | + 0° 62 | 0·917 | 0·5075140 | - 831 | - 6 | - 1045 | + 15 | - 556 | - 56 | 0·5072661 | |
| 137 | 16 36 | 33' 336 | 14' 16 | 17 | 21° 99 | 0° 62 | 0·914 | 0·5076135 | 831 | 8 | 1078 | 15 | 543 | 56 | 0·5073634 | |
| 140 | 17 32 | 34' 084 | 14' 16 | 18 | 22° 60 | 0° 62 | 0·912 | 0·5074441 | 831 | 9 | 1107 | 15 | 553 | 56 | 0·5071900 | |
| 138 | 18 30 | 32' 314 | 14' 16 | 15 | 23° 05 | 0° 62 | 0·910 | 0·5078582 | 831 | 6 | 1129 | 15 | 521 | 56 | 0·5076054 | |
| | | | | | | | | | | | | | Mean | ... | 0·5073562 | |
| | | | | | | | | Time of Vibration of Mean Pendulum | | | | | | | 0·5073563 | |
| | | | | | | | | Do. not applying lag correction | | | | | | | 0·5073560 | |
| 16-17 December, 1904. | | | | | | | | | | | | | | | | |
| 138 | 3 42 | 32' 301 | + 14' 38 | 18 | 22° 39 | - 0° 46 | 0·923 | 0·5078615 | - 844 | - 9 | - 1097 | - 11 | - 528 | - 52 | 0·5076071 | |
| 140 | 4 36 | 34' 075 | 14' 38 | 16 | 21° 87 | 0° 46 | 0·928 | 0·5074459 | 844 | 7 | 1072 | 11 | 562 | 52 | 0·5071911 | |
| 137 | 5 33 | 33' 318 | 14' 38 | 16 | 21° 45 | 0° 46 | 0·929 | 0·5076176 | 844 | 7 | 1051 | 11 | 552 | 52 | 0·5073659 | |
| 139 | 6 30 | 33' 753 | 14' 38 | 16 | 21° 05 | 0° 46 | 0·929 | 0·5075180 | 844 | 7 | 1031 | 11 | 563 | 52 | 0·5072672 | |
| | | | | | | | | | | | | | Mean | ... | 0·5073579 | |
| 138 | 15 47 | 32' 352 | + 14' 38 | 17 | 21° 06 | + 0° 65 | 0·919 | 0·5078487 | - 844 | - 8 | - 1032 | + 16 | - 526 | - 52 | 0·5076041 | |
| 140 | 16 44 | 34' 106 | 14' 38 | 16 | 21° 89 | 0° 65 | 0·916 | 0·5074392 | 844 | 7 | 1073 | 16 | 555 | 52 | 0·5071876 | |
| 137 | 17 42 | 33' 330 | 14' 38 | 17 | 22° 54 | 0° 65 | 0·914 | 0·5076151 | 844 | 8 | 1104 | 16 | 543 | 52 | 0·5073616 | |
| 139 | 18 39 | 33' 739 | 14' 38 | 16 | 23° 00 | 0° 65 | 0·911 | 0·5075212 | 844 | 7 | 1127 | 16 | 552 | 52 | 0·5072646 | |
| | | | | | | | | | | | | | Mean | ... | 0·5073545 | |
| | | | | | | | | Time of Vibration of Mean Pendulum | | | | | | | 0·5073562 | |
| | | | | | | | | Do. not applying lag correction | | | | | | | 0·5073560 | |
| | | | | | | | | General Mean with lag correction | | | | | | | 0·5073557 | |
| | | | | | | | | „ without „ | | | | | | | 0·5073554 | |
| Chatra. | | | | | | | | | | | | | | | | |
| 30-31 December, 1904. | | | | | | | | | | | | | | | | |
| 137 | 3 39 | 33' 505 | + 20' 82 | 15 | 16° 89 | 0° 00 | 0·948 | 0·5075748 | - 1222 | - 6 | - 828 | | - 563 | - 61 | 0·5073068 | |
| 139 | 4 35 | 33' 940 | 20' 82 | 16 | 16° 90 | 0° 00 | 0·948 | 0·5074761 | 1222 | 7 | 828 | | 574 | 61 | 0·5072069 | |
| 138 | 5 34 | 33' 496 | 20' 82 | 17 | 16° 93 | 0° 00 | 0·948 | 0·5078136 | 1222 | 8 | 830 | | 542 | 61 | 0·5075473 | |
| 140 | 6 32 | 34' 291 | 20' 82 | 15 | 16° 86 | 0° 00 | 0·948 | 0·5073983 | 1222 | 6 | 826 | | 574 | 61 | 0·5071294 | |
| | | | | | | | | | | | | | Mean | ... | 0·5072976 | |
| 137 | 15 58 | 33' 509 | + 20' 82 | 15 | 17° 68 | + 0° 63 | 0·936 | 0·5075737 | - 1222 | - 6 | - 866 | | - 556 | - 61 | 0·5073026 | |
| 139 | 16 55 | 33' 909 | 20' 82 | 17 | 18° 56 | 0° 63 | 0·933 | 0·5074830 | 1222 | 8 | 909 | | 565 | 61 | 0·5072065 | |
| 138 | 17 55 | 32' 459 | 20' 82 | 16 | 19° 10 | 0° 63 | 0·930 | 0·5078226 | 1222 | 7 | 936 | | 532 | 61 | 0·5075468 | |
| 140 | 18 54 | 34' 224 | 20' 82 | 16 | 19° 63 | 0° 63 | 0·927 | 0·5074132 | 1222 | 7 | 962 | | 562 | 61 | 0·5071318 | |
| | | | | | | | | | | | | | Mean | ... | 0·5072969 | |
| | | | | | | | | Time of Vibration of Mean Pendulum | | | | | | | 0·5072973 | |
| 31 Dec. 1904—1 Jan. 1905. | | | | | | | | | | | | | | | | |
| 140 | 3 44 | 34' 228 | + 20' 85 | 16 | 18° 19 | - 0° 35 | 0·942 | 0·5074123 | - 1224 | - 7 | - 891 | | - 571 | - 61 | 0·5071369 | |
| 138 | 4 45 | 32' 451 | 20' 85 | 17 | 17° 84 | 0° 35 | 0·945 | 0·5078247 | 1224 | 8 | 874 | | 541 | 61 | 0·5075539 | |
| 139 | 5 40 | 33' 899 | 20' 85 | 16 | 17° 51 | 0° 35 | 0·947 | 0·5074853 | 1224 | 7 | 858 | | 574 | 61 | 0·5072120 | |
| 137 | 6 42 | 33' 484 | 20' 85 | 15 | 17° 21 | 0° 35 | 0·948 | 0·5075795 | 1224 | 6 | 843 | | 563 | 61 | 0·5073098 | |
| | | | | | | | | | | | | | Mean | ... | 0·5073034 | |
| 140 | 16 4 | 34' 311 | + 20' 85 | 17 | 16° 23 | + 0° 90 | 0·944 | 0·5073941 | - 1224 | - 8 | - 795 | | - 572 | - 61 | 0·5071281 | |
| 138 | 17 1 | 32' 505 | 20' 85 | 16 | 17° 05 | 0° 90 | 0·939 | 0·5078113 | 1224 | 7 | 835 | | 537 | 61 | 0·5075449 | |
| 139 | 18 2 | 33' 934 | 20' 85 | 16 | 17° 09 | 0° 90 | 0·933 | 0·5074775 | 1224 | 7 | 882 | | 565 | 61 | 0·5072036 | |
| 137 | 19 2 | 33' 485 | 20' 85 | 17 | 18° 87 | 0° 90 | 0·929 | 0·5075793 | 1224 | 8 | 925 | | 552 | 61 | 0·5073023 | |
| | | | | | | | | | | | | | Mean | ... | 0·5072947 | |
| | | | | | | | | Time of Vibration of Mean Pendulum | | | | | | | 0·5072991 | |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|----------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| 1-2 January, 1905. | | | | | | | | | | | | | | | |
| 139 | 3 58 | 33.893 | + 21.37 | 16 | 17.70 | -0.19 | 0.943 | 0.5074866 | -1254 | -7 | -867 | -571 | -59 | 0.5072138 | |
| 137 | 4 56 | 33.409 | 21.37 | 17 | 17.64 | 0.19 | 0.943 | 0.5075828 | 1254 | 8 | 864 | 560 | 59 | 0.5073083 | |
| 140 | 5 53 | 34.240 | 21.37 | 16 | 17.44 | 0.19 | 0.945 | 0.5074095 | 1254 | 7 | 855 | 573 | 59 | 0.5071347 | |
| 138 | 6 53 | 32.469 | 21.37 | 17 | 17.14 | 0.19 | 0.947 | 0.5078201 | 1254 | 8 | 840 | 542 | 59 | 0.5075498 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073017 |
| 139 | 16 8 | 33.966 | + 21.37 | 16 | 15.46 | +1.04 | 0.947 | 0.5074703 | -1254 | -7 | -758 | -574 | -59 | 0.5072051 | |
| 137 | 17 5 | 33.522 | 21.37 | 17 | 16.52 | 1.04 | 0.937 | 0.5075708 | 1254 | 8 | 809 | 557 | 59 | 0.5073021 | |
| 140 | 18 4 | 34.267 | 21.37 | 16 | 17.64 | 1.04 | 0.932 | 0.5074035 | 1254 | 7 | 864 | 565 | 59 | 0.5071286 | |
| 138 | 19 4 | 32.468 | 21.37 | 17 | 18.50 | 1.04 | 0.928 | 0.5078203 | 1254 | 8 | 907 | 531 | 59 | 0.5075444 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072950 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072984 |
| | | | | | | | | | | | | | General Mean | ... | 0.5072983 |
| Kisnapur. | | | | | | | | | | | | | | | |
| 17-18 January, 1905. | | | | | | | | | | | | | | | |
| 137 | 5 25 | 33.896 | + 8.12 | 17 | 17.50 | -0.34 | 0.940 | 0.5074860 | -477 | -8 | -858 | -558 | -61 | 0.5072898 | |
| 139 | 6 24 | 34.343 | 8.12 | 15 | 17.34 | 0.34 | 0.940 | 0.5073871 | 477 | 6 | 850 | 570 | 61 | 0.5071907 | |
| 138 | 7 25 | 32.872 | 8.12 | 15 | 16.97 | 0.34 | 0.943 | 0.5077227 | 477 | 6 | 832 | 539 | 61 | 0.5075312 | |
| 140 | 8 20 | 34.720 | 8.12 | 17 | 16.56 | 0.34 | 0.945 | 0.5073073 | 477 | 8 | 811 | 573 | 61 | 0.5071143 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072815 |
| 137 | 17 40 | 33.977 | + 8.12 | 19 | 15.32 | +0.79 | 0.939 | 0.5074677 | -477 | -10 | -751 | -558 | -61 | 0.5072820 | |
| 139 | 18 37 | 34.395 | 8.12 | 16 | 16.31 | 0.79 | 0.935 | 0.5073757 | 477 | 7 | 799 | 567 | 61 | 0.5071846 | |
| 138 | 19 38 | 32.902 | 8.12 | 16 | 17.09 | 0.79 | 0.932 | 0.5077153 | 477 | 7 | 837 | 533 | 61 | 0.5075238 | |
| 140 | 20 35 | 35.877 | 8.12 | 15 | 17.69 | 0.79 | 0.929 | 0.5073056 | 477 | 6 | 867 | 563 | 61 | 0.5071082 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072747 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072781 |
| 18-19 January, 1905. | | | | | | | | | | | | | | | |
| 140 | 5 34 | 34.708 | + 8.12 | 16 | 17.26 | -0.11 | 0.938 | 0.5073081 | -477 | -7 | -846 | -568 | -61 | 0.5071122 | |
| 138 | 6 35 | 32.879 | 8.12 | 17 | 17.17 | 0.11 | 0.930 | 0.5077210 | 477 | 8 | 841 | 537 | 61 | 0.5075286 | |
| 139 | 7 31 | 34.362 | 8.12 | 17 | 17.06 | 0.11 | 0.939 | 0.5073830 | 477 | 8 | 836 | 569 | 61 | 0.5071879 | |
| 137 | 8 33 | 33.927 | 8.12 | 18 | 16.93 | 0.11 | 0.940 | 0.5074790 | 477 | 9 | 830 | 558 | 61 | 0.5072855 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072786 |
| 140 | 17 38 | 34.739 | + 8.12 | 16 | 16.25 | +0.80 | 0.941 | 0.5073015 | -477 | -7 | -796 | -570 | -61 | 0.5071104 | |
| 138 | 18 35 | 32.896 | 8.12 | 17 | 16.97 | 0.80 | 0.934 | 0.5077168 | 477 | 8 | 832 | 534 | 61 | 0.5075256 | |
| 139 | 19 34 | 34.359 | 8.12 | 16 | 17.83 | 0.80 | 0.929 | 0.5073836 | 477 | 7 | 874 | 563 | 61 | 0.5071854 | |
| 137 | 20 34 | 33.902 | 8.12 | 15 | 18.59 | 0.80 | 0.927 | 0.5074846 | 477 | 6 | 911 | 551 | 61 | 0.5072840 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072764 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072775 |
| 19-20 January, 1905. | | | | | | | | | | | | | | | |
| 139 | 5 35 | 34.336 | + 8.12 | 17 | 18.02 | -0.06 | 0.933 | 0.5073886 | -477 | -8 | -883 | -565 | -57 | 0.5071896 | |
| 137 | 6 33 | 33.903 | 8.12 | 16 | 17.91 | 0.06 | 0.933 | 0.5074843 | 477 | 7 | 878 | 554 | 57 | 0.5072870 | |
| 140 | 7 34 | 34.692 | 8.12 | 17 | 17.88 | 0.06 | 0.933 | 0.5073117 | 477 | 8 | 876 | 565 | 57 | 0.5071134 | |
| 138 | 8 32 | 32.868 | 8.12 | 17 | 17.84 | 0.06 | 0.933 | 0.5077237 | 477 | 8 | 874 | 534 | 57 | 0.5075287 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072797 |
| 139 | 17 50 | 34.368 | + 8.12 | 17 | 17.07 | +0.75 | 0.931 | 0.5073815 | -477 | -8 | -836 | -564 | -57 | 0.5071873 | |
| 137 | 18 51 | 33.918 | 8.12 | 16 | 17.91 | 0.75 | 0.928 | 0.5074810 | 477 | 7 | 878 | 551 | 57 | 0.5072840 | |
| 140 | 17 50 | 34.686 | 8.12 | 17 | 18.59 | 0.75 | 0.923 | 0.5073129 | 477 | 8 | 911 | 559 | 57 | 0.5071117 | |
| 138 | 20 49 | 32.854 | 8.12 | 18 | 19.23 | 0.75 | 0.921 | 0.5077271 | 477 | 9 | 942 | 527 | 57 | 0.5075259 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072772 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072785 |
| | | | | | | | | | | | | | Mean 17-20 January | ... | 0.5072780 |

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|------------------------------------|----------------|---------------------------|------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| Kisnapur. | | | | | | | | | | | | | | | |
| 21-22 January, 1905. | | | | | | | | | | | | | | | |
| 138 | 5 49 | 32' 875 | + 8' 51 | 17 | 17° 32 | - 0° 13 | 0' 938 | 0' 5077220 | - 500 | - 8 | - 849 | - 537 | - 56 | 0' 5075270 | |
| 140 | 6 43 | 34' 704 | 8' 51 | 16 | 17° 19 | 0° 13 | 0' 938 | 0' 5073091 | 500 | 7 | 842 | 568 | 56 | 0' 5071118 | |
| 137 | 7 41 | 33' 920 | 8' 51 | 16 | 17° 10 | 0° 13 | 0' 939 | 0' 5074807 | 500 | 7 | 838 | 558 | 56 | 0' 5072848 | |
| 139 | 8 40 | 34' 363 | 8' 51 | 16 | 16° 89 | 0° 13 | 0' 939 | 0' 5073826 | 500 | 7 | 828 | 569 | 56 | 0' 5071866 | |
| | | | | | | | | | | | | Mean | ... | 0' 5072776 | |
| 138 | 17 50 | 32' 911 | + 8' 51 | 17 | 16° 17 | + 1° 18 | 0' 937 | 0' 5077135 | - 500 | - 8 | - 792 | - 536 | - 56 | 0' 5075243 | |
| 140 | 18 47 | 34' 723 | 8' 51 | 17 | 16° 09 | 1° 18 | 0' 931 | 0' 5073049 | 500 | 8 | 833 | 564 | 56 | 0' 5071088 | |
| 137 | 19 47 | 33' 910 | 8' 51 | 17 | 18° 26 | 1° 18 | 0' 924 | 0' 5074827 | 500 | 8 | 895 | 549 | 56 | 0' 5072819 | |
| 139 | 20 45 | 34' 321 | 8' 51 | 17 | 19° 39 | 1° 18 | 0' 920 | 0' 5073917 | 500 | 8 | 950 | 558 | 56 | 0' 5071845 | |
| | | | | | | | | | | | | Mean | ... | 0' 5072749 | |
| | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072762 | |
| 22-23 January, 1905. | | | | | | | | | | | | | | | |
| 140 | 5 50 | 34' 657 | + 8' 51 | 17 | 18° 39 | - 0° 26 | 0' 930 | 0' 5073191 | - 500 | - 8 | - 901 | - 564 | - 57 | 0' 5071161 | |
| 138 | 6 49 | 32' 839 | 8' 51 | 17 | 18° 37 | 0° 26 | 0' 931 | 0' 5077308 | 500 | 8 | 900 | 533 | 57 | 0' 5075310 | |
| 139 | 7 48 | 34' 522 | 8' 51 | 16 | 18° 02 | 0° 26 | 0' 933 | 0' 5073916 | 500 | 7 | 883 | 565 | 57 | 0' 5071904 | |
| 137 | 8 45 | 33' 890 | 8' 51 | 16 | 17° 72 | 0° 26 | 0' 934 | 0' 5074873 | 500 | 7 | 868 | 555 | 57 | 0' 5072886 | |
| | | | | | | | | | | | | Mean | ... | 0' 5072815 | |
| 140 | 18 4 | 34' 717 | + 8' 51 | 17 | 16° 69 | + 0° 54 | 0' 932 | 0' 5073062 | - 500 | - 8 | - 818 | - 565 | - 57 | 0' 5071114 | |
| 138 | 19 2 | 32' 880 | 8' 51 | 17 | 17° 09 | 0° 54 | 0' 931 | 0' 5077209 | 500 | 8 | 837 | 533 | 57 | 0' 5075274 | |
| 139 | 19 58 | 34' 348 | 8' 51 | 17 | 17° 58 | 0° 54 | 0' 927 | 0' 5073859 | 500 | 8 | 861 | 562 | 57 | 0' 5071871 | |
| 137 | 20 57 | 33' 896 | 8' 51 | 17 | 18° 25 | 0° 54 | 0' 923 | 0' 5074860 | 500 | 8 | 894 | 548 | 57 | 0' 5072853 | |
| | | | | | | | | | | | | Mean | ... | 0' 5072778 | |
| | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072797 | |
| | | | | | | | | | | | | Mean 21-23 January | ... | 0' 5072780 | |
| | | | | | | | | | | | | General Mean | ... | 0' 5072780 | |
| Jalpaiguri. | | | | | | | | | | | | | | | |
| 31 January-1 February, 1905. | | | | | | | | | | | | | | | |
| 137 | 7 5 | 33' 629 | + 19' 69 | 17 | 15° 06 | + 0° 04 | 0' 934 | 0' 5075463 | - 1156 | - 8 | - 738 | + 1 | - 555 | - 50 | 0' 5072957 |
| 139 | 8 18 | 34' 054 | 19' 69 | 17 | 15° 15 | 0° 04 | 0' 934 | 0' 5074507 | 1156 | 8 | 742 | 1 | 566 | 50 | 0' 5071986 |
| 138 | 9 28 | 32' 603 | 19' 69 | 18 | 15° 18 | 0° 04 | 0' 935 | 0' 5077876 | 1156 | 9 | 744 | 1 | 535 | 50 | 0' 5075383 |
| 140 | 10 29 | 34' 397 | 19' 69 | 17 | 15° 21 | 0° 04 | 0' 934 | 0' 5073752 | 1156 | 8 | 745 | 1 | 566 | 50 | 0' 5071228 |
| | | | | | | | | | | | | Mean | ... | 0' 5072889 | |
| 137 | 19 8 | 33' 637 | + 19' 69 | 18 | 14° 47 | + 0° 12 | 0' 943 | 0' 5075445 | - 1156 | - 9 | - 709 | + 3 | - 560 | - 46 | 0' 5072968 |
| 139 | 20 7 | 34' 070 | 19' 69 | 16 | 14° 65 | 0° 12 | 0' 939 | 0' 5074472 | 1156 | 7 | 718 | 3 | 569 | 46 | 0' 5071979 |
| 138 | 21 15 | 32' 613 | 19' 69 | 16 | 14° 77 | 0° 12 | 0' 939 | 0' 5077850 | 1156 | 7 | 724 | 3 | 537 | 46 | 0' 5075383 |
| 140 | 22 14 | 34' 403 | 19' 69 | 15 | 14° 87 | 0° 12 | 0' 938 | 0' 5073741 | 1156 | 6 | 729 | 3 | 568 | 46 | 0' 5071239 |
| | | | | | | | | | | | | Mean | ... | 0' 5072892 | |
| | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072890 | |
| 1-2 February, 1905. | | | | | | | | | | | | | | | |
| 140 | 6 32 | 34' 402 | + 20° 09 | 18 | 14° 77 | + 0° 01 | 0' 940 | 0' 5073741 | - 1179 | - 9 | - 724 | 0 | - 570 | - 44 | 0' 5071215 |
| 138 | 7 35 | 32' 605 | 20° 09 | 20 | 14° 83 | 0° 01 | 0' 939 | 0' 5077870 | 1179 | 11 | 727 | 0 | 537 | 44 | 0' 5075372 |
| 139 | 8 38 | 34' 062 | 20° 09 | 16 | 14° 83 | 0° 01 | 0' 941 | 0' 5074490 | 1179 | 7 | 727 | 0 | 570 | 44 | 0' 5071963 |
| 137 | 9 48 | 33' 626 | 20° 09 | 15 | 14° 81 | 0° 01 | 0' 940 | 0' 5075469 | 1179 | 6 | 726 | 0 | 558 | 44 | 0' 5072956 |
| | | | | | | | | | | | | Mean | ... | 0' 5072877 | |
| 140 | 19 10 | 34' 980 | + 20° 09 | 17 | 14° 40 | + 0° 10 | 0' 942 | 0' 5073732 | - 1179 | - 8 | - 706 | + 3 | - 571 | - 44 | 0' 5071227 |
| 138 | 20 15 | 32' 613 | 20° 09 | 17 | 14° 52 | 0° 10 | 0' 941 | 0' 5077851 | 1179 | 8 | 711 | 3 | 538 | 44 | 0' 5075374 |
| 139 | 21 18 | 34' 062 | 20° 09 | 18 | 14° 60 | 0° 10 | 0' 940 | 0' 5074488 | 1179 | 9 | 715 | 3 | 570 | 44 | 0' 5071974 |
| 137 | 22 21 | 33' 630 | 20° 09 | 15 | 14° 73 | 0° 10 | 0' 939 | 0' 5075461 | 1179 | 6 | 722 | 3 | 558 | 44 | 0' 5072955 |
| | | | | | | | | | | | | Mean | ... | 0' 5072882 | |
| | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072880 | |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|-----------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|------|----------------|------------------------------------|---------------------------|------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 2-3 February, 1905. | | | | | | | | | | | | | | | | |
| 139 | 6 27 | 34° 064 | + 20° 35 | 16 | 14° 34 | + 0° 02 | 0° 943 | 0° 5074485 | - 1195 | - 7 | - 703 | + 1 | - 571 | - 43 | 0° 5071967 | |
| 137 | 7 41 | 33° 632 | 20° 35 | 12 | 14° 37 | 0° 02 | 0° 943 | 0° 5075455 | 1195 | 4 | 704 | 1 | 560 | 43 | 0° 5072950 | |
| 140 | 8 44 | 34° 407 | 20° 35 | 13 | 14° 38 | 0° 02 | 0° 941 | 0° 5073731 | 1195 | 5 | 705 | 1 | 570 | 43 | 0° 5071214 | |
| 138 | 9 47 | 32° 610 | 20° 35 | 17 | 14° 42 | 0° 02 | 0° 941 | 0° 5077858 | 1195 | 8 | 707 | 1 | 538 | 43 | 0° 5075368 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072875 |
| 139 | 19 4 | 34° 066 | + 20° 35 | 17 | 14° 13 | + 0° 09 | 0° 944 | 0° 5074480 | - 1195 | - 8 | - 692 | + 2 | - 572 | - 42 | 0° 5071973 | |
| 137 | 20 9 | 33° 645 | 20° 35 | 14 | 14° 28 | 0° 09 | 0° 944 | 0° 5075426 | 1195 | 5 | 700 | 2 | 561 | 42 | 0° 5072925 | |
| 140 | 21 11 | 34° 409 | 20° 35 | 16 | 14° 37 | 0° 09 | 0° 943 | 0° 5073727 | 1195 | 7 | 704 | 2 | 571 | 42 | 0° 5071210 | |
| 138 | 22 18 | 32° 611 | 20° 35 | 16 | 14° 43 | 0° 09 | 0° 940 | 0° 5077855 | 1195 | 7 | 707 | 2 | 538 | 42 | 0° 5075368 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072869 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0° 5072872 |
| | | | | | | | | | | | | | | General Mean | ... | 0° 5072881 |
| Kesarbari. | | | | | | | | | | | | | | | | |
| 14-15 February, 1905. | | | | | | | | | | | | | | | | |
| 137 | 7 49 | 34° 122 | + 2° 16 | 17 | 15° 92 | + 0° 13 | 0° 937 | 0° 5074356 | - 127 | - 8 | - 780 | + 3 | - 557 | - 71 | 0° 5072816 | |
| 139 | 8 47 | 34° 563 | 2° 16 | 15 | 15° 98 | 0° 13 | 0° 937 | 0° 5073393 | 127 | 6 | 783 | 3 | 568 | 71 | 0° 5071841 | |
| 138 | 9 45 | 33° 071 | 2° 16 | 15 | 16° 10 | 0° 13 | 0° 934 | 0° 5076755 | 127 | 6 | 789 | 3 | 534 | 71 | 0° 5075231 | |
| 140 | 10 42 | 34° 911 | 2° 16 | 15 | 16° 30 | 0° 13 | 0° 933 | 0° 5072652 | 127 | 6 | 799 | 3 | 565 | 71 | 0° 5071087 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072744 |
| 137 | 19 57 | 34° 128 | + 2° 16 | 15 | 15° 24 | + 0° 49 | 0° 934 | 0° 5074345 | - 127 | - 6 | - 747 | + 12 | - 555 | - 71 | 0° 5072851 | |
| 139 | 20 56 | 34° 570 | 2° 16 | 14 | 15° 82 | 0° 49 | 0° 934 | 0° 5073379 | 127 | 5 | 775 | 12 | 566 | 71 | 0° 5071847 | |
| 138 | 21 54 | 33° 055 | 2° 16 | 14 | 16° 53 | 0° 49 | 0° 934 | 0° 5076793 | 127 | 5 | 809 | 12 | 534 | 71 | 0° 5075259 | |
| 140 | 22 46 | 34° 899 | 2° 16 | 14 | 16° 40 | 0° 49 | 0° 935 | 0° 5072676 | 127 | 5 | 804 | 12 | 567 | 71 | 0° 5071114 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072768 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0° 5072756 |
| | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0° 5072748 |
| 15-16 February, 1905. | | | | | | | | | | | | | | | | |
| 140 | 6 59 | 34° 900 | + 2° 16 | 13 | 16° 04 | + 0° 17 | 0° 938 | 0° 5072675 | - 127 | - 5 | - 786 | + 4 | - 568 | - 71 | 0° 5071122 | |
| 138 | 7 58 | 33° 052 | 2° 16 | 16 | 16° 26 | 0° 17 | 0° 938 | 0° 5076800 | 127 | 7 | 797 | 4 | 537 | 71 | 0° 5075265 | |
| 139 | 8 56 | 34° 537 | 2° 16 | 16 | 16° 40 | 0° 17 | 0° 937 | 0° 5073450 | 127 | 7 | 804 | 4 | 568 | 71 | 0° 5071877 | |
| 137 | 9 55 | 34° 093 | 2° 16 | 14 | 16° 55 | 0° 17 | 0° 935 | 0° 5074421 | 127 | 5 | 811 | 4 | 555 | 71 | 0° 5072856 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072780 |
| 140 | 19 53 | 34° 897 | + 2° 16 | 16 | 15° 98 | + 0° 32 | 0° 937 | 0° 5072681 | - 127 | - 7 | - 783 | + 8 | - 568 | - 71 | 0° 5071133 | |
| 138 | 20 49 | 33° 043 | 2° 16 | 17 | 16° 35 | 0° 32 | 0° 934 | 0° 5076821 | 127 | 8 | 801 | 8 | 534 | 71 | 0° 5075288 | |
| 139 | 21 43 | 34° 524 | 2° 16 | 16 | 16° 72 | 0° 32 | 0° 933 | 0° 5073478 | 127 | 7 | 819 | 8 | 565 | 71 | 0° 5071897 | |
| 137 | 22 40 | 34° 077 | 2° 16 | 16 | 16° 84 | 0° 32 | 0° 933 | 0° 5074456 | 127 | 7 | 825 | 8 | 554 | 71 | 0° 5072880 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072799 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0° 5072790 |
| | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0° 5072784 |
| 16-17 February, 1905. | | | | | | | | | | | | | | | | |
| 137 | 7 14 | 34° 074 | + 2° 17 | 18 | 16° 74 | + 0° 07 | 0° 934 | 0° 5074463 | - 127 | - 9 | - 820 | + 2 | - 555 | - 71 | 0° 5072883 | |
| 139 | 8 9 | 34° 529 | 2° 17 | 19 | 16° 84 | 0° 07 | 0° 934 | 0° 5073467 | 127 | 10 | 825 | 2 | 566 | 71 | 0° 5071870 | |
| 138 | 9 5 | 33° 024 | 2° 17 | 16 | 16° 90 | 0° 07 | 0° 934 | 0° 5076867 | 127 | 7 | 828 | 2 | 534 | 71 | 0° 5075302 | |
| 140 | 10 0 | 34° 865 | 2° 17 | 15 | 16° 93 | 0° 07 | 0° 937 | 0° 5072748 | 127 | 6 | 830 | 2 | 568 | 71 | 0° 5171148 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072801 |
| 137 | 20 18 | 34° 076 | + 2° 17 | 17 | 16° 51 | + 0° 17 | 0° 934 | 0° 5074458 | - 127 | - 8 | - 809 | + 4 | - 555 | - 71 | 0° 5072892 | |
| 139 | 21 12 | 34° 514 | 2° 17 | 16 | 16° 89 | 0° 17 | 0° 931 | 0° 5073500 | 127 | 7 | 828 | 4 | 564 | 71 | 0° 5071907 | |
| 138 | 22 10 | 33° 019 | 2° 17 | 15 | 16° 97 | 0° 17 | 0° 931 | 0° 5076880 | 127 | 6 | 832 | 4 | 533 | 71 | 0° 5075315 | |
| 140 | 22 5 | 34° 854 | 2° 17 | 15 | 17° 09 | 0° 17 | 0° 931 | 0° 5072771 | 127 | 6 | 837 | 4 | 564 | 71 | 0° 5071170 | |
| | | | | | | | | | | | | | | Mean | ... | 0° 5072821 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0° 5072811 |
| | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0° 5072808 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|------|----------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| 17-18 February, 1905. | | | | | | | | | | | | | | | |
| 140 | 7 18 | 34' 85.3 | + 2.17 | 16 | 17° 18 | + 0.14 | 0.933 | 0.5072773 | - 127 | - 7 | - 842 | + 4 | - 565 | - 71 | 0.5071165 |
| 138 | 8 17 | 33' 00.5 | 2.17 | 16 | 17° 35 | 0.14 | 0.931 | 0.5076911 | 127 | 7 | 850 | 4 | 533 | 71 | 0.5075327 |
| 139 | 9 11 | 34' 49.4 | 2.17 | 15 | 17° 48 | 0.14 | 0.932 | 0.5073542 | 127 | 6 | 857 | 4 | 565 | 71 | 0.5071920 |
| 137 | 10 8 | 34' 05.0 | 2.17 | 15 | 17° 58 | 0.14 | 0.932 | 0.5074516 | 127 | 6 | 861 | 4 | 554 | 71 | 0.5072901 |
| Mean | | | | | | | | | | | | | | ... | 0.5072828 |
| 140 | 20 5 | 34' 83.6 | + 2.17 | 16 | 17° 35 | + 0.35 | 0.931 | 0.5072811 | - 127 | - 7 | - 850 | + 9 | - 564 | - 71 | 0.5071201 |
| 138 | 21 6 | 32' 99.5 | 2.17 | 16 | 17° 75 | 0.35 | 0.931 | 0.5076935 | 127 | 7 | 870 | 9 | 533 | 71 | 0.5075336 |
| 139 | 22 2 | 34' 47.3 | 2.17 | 16 | 18° 11 | 0.35 | 0.926 | 0.5073588 | 127 | 7 | 887 | 9 | 561 | 71 | 0.5071944 |
| 137 | 23 10 | 34' 02.1 | 2.17 | 14 | 18° 38 | 0.35 | 0.924 | 0.5074580 | 127 | 5 | 901 | 9 | 549 | 71 | 0.5072936 |
| Mean | | | | | | | | | | | | | | ... | 0.5072854 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072841 |
| Do. not applying lag correction | | | | | | | | | | | | | | ... | 0.5072835 |
| General Mean with | | | | | | | | | | | | | | ... | 0.5072799 |
| " without | | | | | | | | | | | | | | ... | 0.5072794 |
| Ramchandpur. | | | | | | | | | | | | | | | |
| 25-26 February, 1905. | | | | | | | | | | | | | | | |
| 137 | 8 44 | 34' 14.3 | - 0.84 | 16 | 17° 65 | - 0.04 | 0.932 | 0.5074309 | + 49 | - 7 | - 865 | - 1 | - 554 | - 69 | 0.5072862 |
| 139 | 9 42 | 34' 58.8 | 0.84 | 16 | 17° 51 | 0.04 | 0.933 | 0.5073340 | 49 | 7 | 858 | 1 | 565 | 69 | 0.5071889 |
| 138 | 10 39 | 33' 09.6 | 0.84 | 15 | 17° 46 | 0.04 | 0.932 | 0.5076698 | 49 | 6 | 856 | 1 | 533 | 69 | 0.5075282 |
| 140 | 11 35 | 34' 96.9 | 0.84 | 16 | 17° 56 | 0.04 | 0.932 | 0.5072529 | 49 | 7 | 860 | 1 | 565 | 69 | 0.5071076 |
| Mean | | | | | | | | | | | | | | ... | 0.5072777 |
| 137 | 20 34 | 34' 17.2 | - 0.84 | 17 | 17° 24 | + 0.39 | 0.931 | 0.5074245 | + 49 | - 8 | - 845 | + 10 | - 553 | - 69 | 0.5072829 |
| 139 | 21 27 | 34' 60.5 | 0.84 | 16 | 17° 63 | 0.39 | 0.929 | 0.5073303 | 49 | 7 | 864 | 10 | 563 | 69 | 0.5071859 |
| 138 | 22 22 | 33' 10.0 | 0.84 | 17 | 17° 99 | 0.39 | 0.926 | 0.5076688 | 49 | 8 | 882 | 10 | 530 | 69 | 0.5075258 |
| 140 | 22 18 | 34' 95.0 | 0.84 | 16 | 18° 28 | 0.39 | 0.924 | 0.5072568 | 49 | 7 | 896 | 10 | 560 | 69 | 0.5071095 |
| Mean | | | | | | | | | | | | | | ... | 0.5072760 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072769 |
| Do. not applying lag correction | | | | | | | | | | | | | | ... | 0.5072764 |
| 26-27 February, 1905. | | | | | | | | | | | | | | | |
| 140 | 7 51 | 34' 93.4 | - 0.18 | 16 | 17° 90 | - 0.09 | 0.932 | 0.5072603 | + 12 | - 7 | - 877 | - 2 | - 565 | - 68 | 0.5071096 |
| 138 | 8 48 | 33' 09.2 | 0.18 | 15 | 17° 83 | 0.09 | 0.933 | 0.5076707 | 12 | 6 | 874 | 2 | 534 | 68 | 0.5075235 |
| 139 | 9 56 | 34' 64.1 | 0.18 | 15 | 17° 71 | 0.09 | 0.933 | 0.5073226 | 12 | 6 | 868 | 2 | 565 | 68 | 0.5071729 |
| 137 | 10 53 | 34' 14.3 | 0.18 | 15 | 17° 67 | 0.09 | 0.933 | 0.5074312 | 12 | 6 | 866 | 2 | 554 | 68 | 0.5072828 |
| Mean | | | | | | | | | | | | | | ... | 0.5072722 |
| 140 | 20 15 | 34' 91.5 | - 0.18 | 16 | 19° 38 | + 0.10 | 0.925 | 0.5072643 | + 12 | - 7 | - 950 | + 3 | - 561 | - 68 | 0.5071072 |
| 138 | 21 13 | 33' 06.3 | 0.18 | 18 | 19° 39 | 0.10 | 0.934 | 0.5076773 | 12 | 9 | 950 | 3 | 534 | 68 | 0.5075227 |
| 139 | 22 9 | 34' 54.4 | 0.18 | 15 | 19° 49 | 0.10 | 0.933 | 0.5073435 | 12 | 6 | 955 | 3 | 565 | 68 | 0.5071856 |
| 137 | 23 11 | 34' 10.1 | 0.18 | 15 | 19° 66 | 0.10 | 0.932 | 0.5074403 | 12 | 6 | 963 | 3 | 554 | 68 | 0.5072827 |
| Mean | | | | | | | | | | | | | | ... | 0.5072746 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072734 |
| Do. not applying lag correction | | | | | | | | | | | | | | ... | 0.5072733 |
| 27-28 February, 1905. | | | | | | | | | | | | | | | |
| 139 | 7 48 | 34' 51.9 | + 0.71 | 16 | 18° 93 | - 0.01 | 0.927 | 0.5073490 | - 42 | - 7 | - 928 | 0 | - 562 | - 66 | 0.5071885 |
| 137 | 8 44 | 34' 08.6 | 0.71 | 15 | 18° 91 | 0.01 | 0.926 | 0.5074436 | 42 | 6 | 927 | 0 | 550 | 66 | 0.5072845 |
| 140 | 9 42 | 34' 88.4 | 0.71 | 16 | 18° 87 | 0.01 | 0.927 | 0.5072708 | 42 | 7 | 925 | 0 | 562 | 66 | 0.5071106 |
| 138 | 10 41 | 33' 03.8 | 0.71 | 15 | 18° 93 | 0.01 | 0.926 | 0.5076832 | 42 | 6 | 928 | 0 | 530 | 66 | 0.5075260 |
| Mean | | | | | | | | | | | | | | ... | 0.5072774 |
| 139 | 20 24 | 34' 51.3 | + 0.71 | 16 | 20° 08 | + 0.32 | 0.921 | 0.5073501 | - 42 | - 7 | - 984 | + 8 | - 558 | - 66 | 0.5071852 |
| 137 | 21 27 | 34' 06.2 | 0.71 | 15 | 20° 24 | 0.32 | 0.918 | 0.5074490 | 42 | 6 | 992 | 8 | 545 | 66 | 0.5072847 |
| 140 | 22 34 | 34' 85.3 | 0.71 | 15 | 20° 64 | 0.32 | 0.915 | 0.5072773 | 42 | 6 | 1011 | 8 | 554 | 66 | 0.5071102 |
| 138 | 23 39 | 33' 00.3 | 0.71 | 15 | 21° 02 | 0.32 | 0.913 | 0.5076916 | 42 | 6 | 1030 | 8 | 522 | 66 | 0.5075258 |
| Mean | | | | | | | | | | | | | | ... | 0.5072765 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072769 |
| Do. not applying lag correction | | | | | | | | | | | | | | ... | 0.5072765 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | | |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|----------------|---------|------------------------------------|-----------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | | |
| Siliguri. | | | | | | | | | | | | | | | | | |
| 12-13 March, 1905. | | | | | | | | | | | | | | | | | |
| 137 | 9 28 | 33.980 | + | 1.79 | 16 | 18.97 | +0.01 | 0.915 | 0.5074672 | -105 | -7 | -930 | 0 | -542 | -64 | 0.5073024 | |
| 139 | 10 23 | 34.415 | | 1.79 | 17 | 19.07 | 0.01 | 0.910 | 0.5073712 | 105 | 8 | 934 | 0 | 551 | 64 | 0.5072050 | |
| 138 | 11 20 | 32.934 | | 1.79 | 16 | 19.06 | 0.01 | 0.910 | 0.5077980 | 105 | 7 | 934 | 0 | 521 | 64 | 0.5075449 | |
| 140 | 12 19 | 34.767 | | 1.79 | 15 | 19.01 | 0.01 | 0.912 | 0.5072957 | 105 | 6 | 931 | 0 | 553 | 64 | 0.5071298 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072955 |
| 137 | 21 41 | 33.992 | + | 1.79 | 18 | 18.41 | +0.41 | 0.914 | 0.5074646 | -105 | -9 | -902 | +10 | -543 | -64 | 0.5073033 | |
| 139 | 22 34 | 34.422 | | 1.79 | 18 | 18.73 | 0.41 | 0.912 | 0.5073699 | 105 | 9 | 918 | 10 | 553 | 64 | 0.5072060 | |
| 138 | 23 35 | 32.930 | | 1.79 | 16 | 19.13 | 0.41 | 0.909 | 0.5077090 | 105 | 7 | 937 | 10 | 520 | 64 | 0.5075467 | |
| 140 | 0 31 | 34.748 | | 1.79 | 15 | 19.56 | 0.41 | 0.906 | 0.5072996 | 105 | 6 | 958 | 10 | 549 | 64 | 0.5071324 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072971 |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072963 |
| | | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0.5072958 |
| 13-14 March, 1905. | | | | | | | | | | | | | | | | | |
| 140 | 9 6 | 34.718 | + | 2.57 | 14 | 19.83 | +0.02 | 0.912 | 0.5073060 | -151 | -5 | -972 | +1 | -553 | -64 | 0.5071316 | |
| 138 | 10 5 | 32.892 | | 2.57 | 16 | 19.81 | 0.02 | 0.912 | 0.5077179 | 151 | 7 | 971 | 1 | 522 | 64 | 0.5075465 | |
| 139 | 11 1 | 34.376 | | 2.57 | 14 | 19.80 | 0.02 | 0.912 | 0.5073798 | 151 | 5 | 970 | 1 | 553 | 64 | 0.5072056 | |
| 137 | 12 4 | 33.933 | | 2.57 | 16 | 19.89 | 0.02 | 0.912 | 0.5074777 | 151 | 7 | 975 | 1 | 542 | 64 | 0.5073039 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072969 |
| 140 | 21 32 | 34.729 | + | 2.57 | 17 | 19.56 | +0.33 | 0.913 | 0.5073038 | -151 | -8 | -958 | +8 | -553 | -64 | 0.5071312 | |
| 138 | 22 28 | 32.894 | | 2.57 | 18 | 19.82 | 0.33 | 0.910 | 0.5077173 | 151 | 9 | 971 | 8 | 521 | 64 | 0.5075465 | |
| 139 | 23 26 | 34.371 | | 2.57 | 16 | 20.14 | 0.33 | 0.907 | 0.5073810 | 151 | 7 | 987 | 8 | 550 | 64 | 0.5072059 | |
| 137 | 0 25 | 33.922 | | 2.57 | 15 | 20.49 | 0.33 | 0.905 | 0.5074800 | 151 | 5 | 1004 | 8 | 538 | 64 | 0.5073045 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072970 |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072970 |
| | | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0.5072965 |
| 14-15 March, 1905. | | | | | | | | | | | | | | | | | |
| 139 | 8 50 | 34.348 | + | 2.80 | 16 | 20.48 | -0.04 | 0.908 | 0.5073859 | -164 | -7 | -1004 | -1 | -550 | -64 | 0.5072069 | |
| 137 | 9 47 | 33.910 | | 2.80 | 16 | 20.43 | 0.04 | 0.908 | 0.5074828 | 164 | 7 | 1001 | 1 | 539 | 64 | 0.5073052 | |
| 140 | 10 42 | 34.701 | | 2.80 | 16 | 20.40 | 0.04 | 0.908 | 0.5073098 | 164 | 7 | 1000 | 1 | 550 | 64 | 0.5071312 | |
| 138 | 11 38 | 32.872 | | 2.80 | 17 | 20.36 | 0.04 | 0.908 | 0.5077228 | 164 | 8 | 998 | 1 | 519 | 64 | 0.5075474 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072977 |
| 139 | 21 24 | 34.363 | + | 2.80 | 16 | 19.84 | +0.32 | 0.911 | 0.5073826 | -164 | -7 | -972 | +8 | -552 | -64 | 0.5072075 | |
| 137 | 22 18 | 33.918 | | 2.80 | 16 | 20.03 | 0.32 | 0.908 | 0.5074810 | 164 | 7 | 981 | 8 | 539 | 64 | 0.5073063 | |
| 140 | 23 14 | 34.701 | | 2.80 | 15 | 20.30 | 0.32 | 0.906 | 0.5073097 | 164 | 6 | 995 | 8 | 549 | 64 | 0.5071327 | |
| 138 | 0 12 | 32.869 | | 2.80 | 16 | 20.80 | 0.32 | 0.903 | 0.5077236 | 164 | 7 | 1019 | 8 | 517 | 64 | 0.5075473 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072984 |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072980 |
| | | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0.5072977 |
| 15-16 March, 1905. | | | | | | | | | | | | | | | | | |
| 138 | 9 21 | 32.846 | + | 3.47 | 16 | 21.03 | -0.09 | 0.907 | 0.5077290 | -204 | -7 | -1030 | -2 | -519 | -64 | 0.5075464 | |
| 140 | 10 13 | 34.672 | | 3.47 | 14 | 20.88 | 0.09 | 0.907 | 0.5073160 | 204 | 5 | 1023 | 2 | 550 | 64 | 0.5071312 | |
| 137 | 11 10 | 33.886 | | 3.47 | 14 | 20.80 | 0.09 | 0.906 | 0.5074880 | 204 | 5 | 1019 | 2 | 538 | 64 | 0.5073048 | |
| 139 | 12 5 | 34.323 | | 3.47 | 15 | 20.78 | 0.09 | 0.906 | 0.5073915 | 204 | 6 | 1018 | 2 | 549 | 64 | 0.5072072 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072974 |
| 138 | 21 37 | 32.849 | + | 3.47 | 17 | 20.75 | +0.32 | 0.905 | 0.5077282 | -204 | -8 | -1017 | +8 | -518 | -64 | 0.5075479 | |
| 140 | 22 30 | 34.688 | | 3.47 | 16 | 20.98 | 0.32 | 0.903 | 0.5073127 | 204 | 7 | 1028 | 8 | 547 | 64 | 0.5071285 | |
| 137 | 23 25 | 33.901 | | 3.47 | 15 | 21.28 | 0.32 | 0.900 | 0.5074849 | 204 | 6 | 1043 | 8 | 535 | 64 | 0.5073005 | |
| 139 | 0 26 | 34.338 | | 3.47 | 17 | 21.65 | 0.32 | 0.897 | 0.5073883 | 204 | 8 | 1061 | 8 | 544 | 64 | 0.5072010 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072945 |
| | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072960 |
| | | | | | | | | | | | | | | | Do. not applying lag correction | ... | 0.5072957 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|--------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|------------------------------------|---------|---------------------------|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 28-29 March, 1905. | | | | | | | | | | | | | | | | |
| 140 | h 56 | s 34.358 | + 8.98 | 14 | 16.50 | -0.10 | 0.784 | 0.5073837 | -527 | -5 | -809 | -3 | -475 | -35 | 0.5071983 | |
| 138 | 10 53 | 32.570 | 8.98 | 18 | 16.40 | 0.10 | 0.784 | 0.5077953 | 527 | 9 | 804 | 3 | 448 | 35 | 0.5076127 | |
| 139 | 11 47 | 34.019 | 8.98 | 16 | 16.33 | 0.10 | 0.784 | 0.5074585 | 527 | 7 | 800 | 3 | 475 | 35 | 0.5072738 | |
| 137 | 12 43 | 33.595 | 8.98 | 14 | 16.21 | 0.10 | 0.782 | 0.5075542 | 527 | 5 | 794 | 3 | 465 | 35 | 0.5073713 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073640 | |
| 140 | 22 31 | 34.352 | + 8.98 | 17 | 16.59 | +0.12 | 0.783 | 0.5073852 | -527 | -8 | -813 | +3 | -474 | -35 | 0.5071998 | |
| 138 | 23 29 | 32.566 | 8.98 | 16 | 16.05 | 0.12 | 0.781 | 0.5077965 | 527 | 7 | 816 | 3 | 447 | 35 | 0.5076136 | |
| 139 | 0 24 | 34.010 | 8.98 | 16 | 16.77 | 0.12 | 0.781 | 0.5074606 | 527 | 7 | 822 | 3 | 473 | 35 | 0.5072745 | |
| 137 | 1 22 | 33.575 | 8.98 | 15 | 16.91 | 0.12 | 0.778 | 0.5075586 | 527 | 6 | 829 | 3 | 462 | 35 | 0.5073730 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073652 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5073646 | |
| 29-30 March, 1905. | | | | | | | | | | | | | | | | |
| 139 | 9 46 | 34.007 | + 9.03 | 18 | 16.64 | -0.03 | 0.780 | 0.5074610 | -530 | -9 | -815 | -1 | -473 | -35 | 0.5072747 | |
| 137 | 10 42 | 33.581 | 9.03 | 16 | 16.67 | 0.03 | 0.781 | 0.5075572 | 530 | 7 | 817 | 1 | 464 | 35 | 0.5073718 | |
| 140 | 11 38 | 34.347 | 9.03 | 16 | 16.59 | 0.03 | 0.779 | 0.5073861 | 530 | 7 | 813 | 1 | 472 | 35 | 0.5072003 | |
| 138 | 12 34 | 32.593 | 9.03 | 18 | 16.62 | 0.03 | 0.779 | 0.5077973 | 530 | 9 | 814 | 1 | 446 | 35 | 0.5076138 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073652 | |
| 139 | 22 38 | 34.010 | + 9.03 | 16 | 16.44 | +0.17 | 0.781 | 0.5074606 | -530 | -7 | -806 | +4 | -473 | -35 | 0.5072759 | |
| 137 | 23 33 | 33.582 | 9.03 | 14 | 16.54 | 0.17 | 0.781 | 0.5075571 | 530 | 5 | 810 | 4 | 464 | 35 | 0.5073731 | |
| 140 | 0 35 | 34.344 | 9.03 | 14 | 16.74 | 0.17 | 0.778 | 0.5073868 | 530 | 5 | 820 | 4 | 471 | 35 | 0.5072011 | |
| 138 | 1 32 | 32.554 | 9.03 | 16 | 16.88 | 0.17 | 0.778 | 0.5077995 | 530 | 7 | 827 | 4 | 445 | 35 | 0.5076155 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073664 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5073658 | |
| 31 March--1 April, 1905. | | | | | | | | | | | | | | | | |
| 138 | 9 55 | 32.558 | + 9.73 | 15 | 15.70 | -0.06 | 0.781 | 0.5077983 | -571 | -6 | -769 | -2 | -447 | -35 | 0.5076153 | |
| 140 | 10 50 | 34.317 | 9.73 | 15 | 15.66 | 0.06 | 0.781 | 0.5073860 | 571 | 6 | 767 | 2 | 473 | 35 | 0.5072006 | |
| 137 | 11 47 | 33.581 | 9.73 | 14 | 15.65 | 0.06 | 0.781 | 0.5075572 | 571 | 5 | 767 | 2 | 464 | 35 | 0.5073728 | |
| 139 | 12 43 | 34.014 | 9.73 | 17 | 15.48 | 0.06 | 0.781 | 0.5074595 | 571 | 8 | 759 | 2 | 473 | 35 | 0.5072747 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073659 | |
| 138 | 22 58 | 32.594 | + 9.73 | 16 | 14.93 | +0.27 | 0.781 | 0.5077897 | -571 | -7 | -732 | +7 | -447 | -35 | 0.5076112 | |
| 140 | 23 57 | 34.371 | 9.73 | 15 | 15.37 | 0.27 | 0.781 | 0.5073811 | 571 | 6 | 753 | 7 | 473 | 35 | 0.5071980 | |
| 137 | 0 52 | 33.595 | 9.73 | 14 | 15.59 | 0.27 | 0.780 | 0.5075541 | 571 | 5 | 764 | 7 | 463 | 35 | 0.5073710 | |
| 139 | 1 51 | 34.020 | 9.73 | 15 | 15.79 | 0.27 | 0.780 | 0.5074581 | 571 | 6 | 774 | 7 | 473 | 35 | 0.5072729 | |
| | | | | | | | | | | | | | Mean | ... | 0.5073633 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5073646 | |
| Sandakphu. | | | | | | | | | | | | | | | | |
| 10-11 April, 1905. | | | | | | | | | | | | | | | | |
| 137 | h 49 | s 33.472 | + 3.295 | 15 | 7.32 | +0.08 | 0.627 | 0.5075823 | -193 | -6 | -359 | +2 | -372 | -47 | 0.5074848 | |
| 139 | 2 44 | 33.894 | 3.295 | 17 | 7.49 | 0.08 | 0.627 | 0.5074863 | 193 | 8 | 367 | 2 | 380 | 47 | 0.5073870 | |
| 138 | 3 44 | 33.456 | 3.295 | 16 | 7.54 | 0.08 | 0.628 | 0.5078231 | 193 | 7 | 369 | 2 | 359 | 47 | 0.5077258 | |
| 140 | 4 40 | 34.229 | 3.295 | 15 | 7.59 | 0.08 | 0.627 | 0.5074120 | 193 | 6 | 372 | 2 | 380 | 47 | 0.5073124 | |
| | | | | | | | | | | | | | Mean | ... | 0.5074775 | |
| 137 | 13 30 | 33.451 | + 3.295 | 14 | 8.31 | +0.02 | 0.629 | 0.5075871 | -193 | -5 | -407 | +1 | -374 | -47 | 0.5074846 | |
| 139 | 14 24 | 33.878 | 3.295 | 16 | 7.95 | 0.02 | 0.628 | 0.5074900 | 193 | 7 | 390 | 1 | 381 | 47 | 0.5073883 | |
| 138 | 15 20 | 33.445 | 3.295 | 17 | 8.12 | 0.02 | 0.628 | 0.5078260 | 193 | 8 | 398 | 1 | 359 | 47 | 0.5077256 | |
| 140 | 16 18 | 34.218 | 3.295 | 13 | 8.19 | 0.02 | 0.627 | 0.5074146 | 193 | 5 | 401 | 1 | 380 | 47 | 0.5073121 | |
| | | | | | | | | | | | | | Mean | ... | 0.5074777 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5074776 | |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-------|----------------|------------|---------------------------|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 14-15 May, 1905. | | | | | | | | | | | | | | | | |
| 139 | 13 25 | 34' 373 | + 7' 15 | 18 | 24' 75 | - 0' 19 | 0' 845 | 0' 5073806 | - 420 | - 9 | - 1213 | - 512 | - 37 | 0' 5071615 | | |
| 137 | 14 19 | 33' 940 | 7' 15 | 16 | 24' 60 | 0' 10 | 0' 842 | 0' 5074760 | 420 | 7 | 1205 | 500 | 37 | 0' 5072591 | | |
| 140 | 15 14 | 34' 749 | 7' 15 | 16 | 24' 37 | 0' 19 | 0' 840 | 0' 5072995 | 420 | 7 | 1194 | 509 | 37 | 0' 5070828 | | |
| 138 | 16 12 | 32' 907 | 7' 15 | 17 | 24' 27 | 0' 19 | 0' 840 | 0' 5077143 | 420 | 8 | 1189 | 480 | 37 | 0' 5075009 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072511 | | |
| 139 | 1 49 | 34' 394 | + 7' 15 | 18 | 24' 66 | + 0' 57 | 0' 833 | 0' 5073760 | - 420 | - 9 | - 1208 | - 505 | - 37 | 0' 5071581 | | |
| 137 | 2 47 | 33' 947 | 7' 15 | 16 | 25' 00 | 0' 57 | 0' 834 | 0' 5074747 | 420 | 7 | 1225 | 495 | 37 | 0' 5072563 | | |
| 140 | 3 51 | 34' 724 | 7' 15 | 16 | 25' 41 | 0' 57 | 0' 831 | 0' 5073049 | 420 | 7 | 1245 | 504 | 37 | 0' 5070836 | | |
| 138 | 4 53 | 32' 882 | 7' 15 | 17 | 26' 62 | 0' 57 | 0' 824 | 0' 5077205 | 420 | 8 | 1304 | 471 | 37 | 0' 5074965 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072486 | | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0' 5072499 | |
| Dehra Dun—(Pendulum Room). | | | | | | | | | | | | | | | | |
| 17-18 May, 1905. | | | | | | | | | | | | | | | | |
| 137 | 13 49 | 34' 017 | + 0' 04 | 17 | 26' 87 | - 0' 03 | 0' 827 | 0' 5074446 | - 2 | - 8 | - 1316 | - 491 | - 42 | 0' 5072586 | | |
| 130 | 14 47 | 34' 526 | 0' 01 | 17 | 26' 96 | 0' 03 | 0' 826 | 0' 5073473 | 2 | 8 | 1321 | 501 | 42 | 0' 5071598 | | |
| 138 | 15 44 | 33' 031 | 0' 04 | 17 | 26' 91 | 0' 03 | 0' 827 | 0' 5076850 | 2 | 8 | 1319 | 473 | 42 | 0' 5075005 | | |
| 140 | 16 40 | 34' 873 | 0' 04 | 13 | 26' 82 | 0' 03 | 0' 828 | 0' 5072732 | 2 | 5 | 1314 | 502 | 42 | 0' 5070866 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072514 | | |
| 137 | 1 49 | 34' 087 | + 0' 04 | 14 | 26' 85 | + 0' 18 | 0' 827 | 0' 5074435 | - 2 | - 5 | - 1316 | + 491 | - 42 | 0' 5072584 | | |
| 139 | 2 49 | 34' 528 | 0' 04 | 15 | 27' 07 | 0' 18 | 0' 825 | 0' 5073468 | 2 | 6 | 1326 | 500 | 42 | 0' 5071597 | | |
| 138 | 3 47 | 33' 029 | 0' 04 | 15 | 27' 24 | 0' 18 | 0' 825 | 0' 5076855 | 2 | 6 | 1335 | 472 | 42 | 0' 5075003 | | |
| 140 | 4 42 | 34' 866 | 0' 04 | 14 | 27' 37 | 0' 18 | 0' 825 | 0' 5072747 | 2 | 5 | 1341 | 500 | 42 | 0' 5070862 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072512 | | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0' 5072513 | |
| 18-19 May, 1905. | | | | | | | | | | | | | | | | |
| 140 | 13 34 | 34' 858 | - 0' 52 | 14 | 27' 38 | - 0' 05 | 0' 826 | 0' 5072763 | + 31 | - 5 | - 1342 | - 501 | - 42 | 0' 5070903 | | |
| 138 | 14 31 | 33' 019 | 0' 52 | 17 | 27' 33 | 0' 05 | 0' 826 | 0' 5076876 | 31 | 8 | 1339 | 472 | 42 | 0' 5075045 | | |
| 139 | 15 28 | 34' 511 | 0' 52 | 16 | 27' 33 | 0' 05 | 0' 826 | 0' 5073506 | 31 | 7 | 1339 | 501 | 42 | 0' 5071647 | | |
| 137 | 16 23 | 34' 066 | 0' 52 | 14 | 27' 21 | 0' 05 | 0' 827 | 0' 5074480 | 31 | 5 | 1333 | 491 | 42 | 0' 5072639 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072559 | | |
| 140 | 2 5 | 34' 886 | - 0' 52 | 16 | 27' 11 | + 0' 16 | 0' 826 | 0' 5072705 | + 31 | - 7 | - 1328 | + 491 | - 42 | 0' 5070862 | | |
| 138 | 3 0 | 33' 071 | 0' 52 | 17 | 27' 29 | 0' 16 | 0' 825 | 0' 5076753 | 31 | 8 | 1337 | 472 | 42 | 0' 5074929 | | |
| 139 | 3 56 | 34' 579 | 0' 52 | 16 | 27' 42 | 0' 16 | 0' 825 | 0' 5073359 | 31 | 7 | 1344 | 500 | 42 | 0' 5071501 | | |
| 137 | 4 56 | 34' 121 | 0' 52 | 15 | 27' 57 | 0' 16 | 0' 822 | 0' 5074360 | 31 | 6 | 1351 | 488 | 42 | 0' 5072508 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072450 | | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0' 5072504 | |
| 19-20 May, 1905. | | | | | | | | | | | | | | | | |
| 139 | 13 51 | 34' 560 | - 1' 80 | 15 | 27' 67 | - 0' 20 | 0' 826 | 0' 5073400 | + 106 | - 6 | - 1356 | - 501 | - 42 | 0' 5071596 | | |
| 137 | 14 47 | 34' 120 | 1' 80 | 12 | 27' 42 | 0' 20 | 0' 828 | 0' 5074362 | 106 | 4 | 1344 | 492 | 42 | 0' 5072581 | | |
| 140 | 15 42 | 34' 914 | 1' 80 | 14 | 27' 18 | 0' 20 | 0' 829 | 0' 5072646 | 106 | 5 | 1332 | 502 | 42 | 0' 5070866 | | |
| 138 | 16 37 | 33' 068 | 1' 80 | 15 | 27' 19 | 0' 20 | 0' 829 | 0' 5076762 | 106 | 6 | 1332 | 474 | 42 | 0' 5075009 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072513 | | |
| 139 | 1 56 | 34' 573 | - 1' 80 | 16 | 27' 39 | + 0' 19 | 0' 826 | 0' 5073371 | + 106 | - 7 | - 1342 | + 501 | - 42 | 0' 5071590 | | |
| 137 | 2 52 | 34' 119 | 1' 80 | 13 | 27' 65 | 0' 19 | 0' 824 | 0' 5074363 | 106 | 4 | 1355 | 489 | 42 | 0' 5072584 | | |
| 140 | 3 48 | 34' 913 | 1' 80 | 13 | 27' 78 | 0' 19 | 0' 824 | 0' 5072647 | 106 | 5 | 1361 | 499 | 42 | 0' 5070851 | | |
| 138 | 4 44 | 33' 056 | 1' 80 | 15 | 27' 93 | 0' 19 | 0' 824 | 0' 5076790 | 106 | 6 | 1369 | 471 | 42 | 0' 5075013 | | |
| | | | | | | | | | | | | Mean | ... | 0' 5072509 | | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0' 5072511 | |

TIME OF VIBRATION AT DEHRA DUN.

In the accompanying table the results of all the observations at Dehra Dún between November 1904 and May 1905 are collected, the times of vibration of each pendulum being shewn separately.

Table II. Times of Vibration at Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Pendulum room. | | | | | |
| <i>November 1904.</i> | | | | | |
| Nov. 8—9 | ^s 0·5072594 | ^s 0·5075004 | ^s 0·5071618 | ^s 0·5070834 | ^s 0·5072513 |
| " 9—10 | 2610 | 5024 | 1628 | 0853 | 2520 |
| " 10—11 | 2589 | 5020 | 1618 | 0851 | 2519 |
| " 11—12 | 2602 | 5017 | 1628 | 0856 | 2526 |
| Mean | 0·5072599 | 0·5075016 | 0·5071623 | 0·5070849 | 0·5072522 |
| <i>May 1905.</i> | | | | | |
| May 17—18 | 0·5072585 | 0·5075004 | 0·5071598 | 0·5070864 | 0·5072513 |
| " 18—19 | 2574 | 4987 | 1574 | 0882 | 2504 |
| " 19—20 | 2583 | 5011 | 1593 | 0859 | 2511 |
| Mean | 0·5072581 | 0·5075001 | 0·5071588 | 0·5070868 | 0·5072509 |
| Change May—Nov. | — 18 | — 15 | — 35 | + 19 | — 13 |
| Field station (Tent). | | | | | |
| <i>November 1904.</i> | | | | | |
| Nov. 21—22 | ^s 0·5072573 | ^s 0·5074987 | ^s 0·5071593 | ^s 0·5070837 | ^s 0·5072497 |
| " 22—23 | 2596 | 4996 | 1614 | 0835 | 2510 |
| Mean | 0·5072585 | 0·5074992 | 0·5071604 | 0·5070836 | 0·5072504 |
| <i>May 1905.</i> | | | | | |
| May 12—13 | 0·5072571 | 0·5074995 | 0·5071600 | 0·5070849 | 0·5072504 |
| " 13—14 | 2576 | 4995 | 1598 | 0848 | 2504 |
| " 14—15 | 2577 | 4987 | 1598 | 0832 | 2499 |
| Mean | 0·5072575 | 0·5074992 | 0·5071599 | 0·5070843 | 0·5072502 |
| Change May—Nov. | — 10 | 0 | — 5 | + 7 | — 2 |

The accordance between the values obtained in new pendulum room is by no means satisfactory and it appears possible that some change in the lengths of the pendulums may have taken place. The observations in the tent do not support this idea, but in an unsteady temperature, such as that met with in the tent, great reliance cannot be placed on the results.

To examine into the question of a possible change in the lengths of the pendulums, the differences between the time of vibration of each and the mean of the four have been taken out for each station, and tabulated. If there has been any change,—other than one in the same direction and of the same amount in all,—it will be revealed by a change in these differences.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

| Station | Date | 137 | v | 138 | v | 139 | v | 140 | v |
|-------------------------|----------------|------|-----|--------|------|-------|------|--------|------|
| Dehra Dun Pendulum Room | 1904-05 | | | | | | | | |
| | Nov. 8-9 | - 81 | - 7 | - 2491 | + 1 | + 895 | - 11 | + 1679 | + 19 |
| | " 9-10 | 81 | 7 | 2495 | - 3 | 901 | 5 | 1676 | 16 |
| | " 10-11 | 70 | + 4 | 2501 | 9 | 901 | 5 | 1668 | 8 |
| | " 11-12 | 76 | - 2 | 2491 | + 1 | 898 | 8 | 1670 | 10 |
| Dehra Dun Tent ... | Nov. 21-22 | 76 | - 2 | 2490 | + 2 | 904 | - 2 | 1660 | 0 |
| | " 22-23 | 86 | 12 | 2486 | 6 | 896 | 10 | 1675 | + 15 |
| Cuttack | Dec. 12-13 | 78 | - 4 | 2487 | + 5 | 904 | - 2 | 1661 | + 1 |
| | " 13-14 | 74 | 0 | 2496 | - 4 | 895 | 11 | 1677 | 17 |
| | " 14-15 | 73 | + 1 | 2491 | + 1 | 902 | 4 | 1663 | 3 |
| | " 16-17 | 75 | - 1 | 2496 | - 4 | 903 | 3 | 1668 | 8 |
| Chatra ... | Dec. 30-31 | 74 | 0 | 2498 | - 6 | 906 | 0 | 1667 | + 7 |
| | " 31-Jan. 1 | 69 | + 5 | 2503 | 11 | 908 | + 2 | 1666 | 6 |
| | Jan. 1-2 | 68 | 6 | 2487 | + 5 | 889 | - 17 | 1667 | 7 |
| Kisnapur ... | Jan. 17-18 | 78 | - 4 | 2494 | - 2 | 904 | - 2 | 1669 | + 9 |
| | " 18-19 | 72 | + 2 | 2496 | 4 | 908 | + 2 | 1662 | 2 |
| | " 19-20 | 70 | 4 | 2488 | + 4 | 900 | - 6 | 1660 | 0 |
| | " 21-22 | 71 | 3 | 2495 | - 3 | 906 | 0 | 1659 | - 1 |
| | " 22-23 | 73 | 1 | 2495 | 3 | 910 | + 4 | 1659 | 1 |
| Jalpaiguri ... | Jan. 31-Feb. 1 | 73 | + 1 | 2493 | - 1 | 908 | + 2 | 1656 | - 4 |
| | Feb. 1-2 | 75 | - 1 | 2493 | 1 | 911 | 5 | 1659 | 1 |
| | " 2-3 | 66 | + 8 | 2496 | 4 | 902 | - 4 | 1660 | 0 |
| Kesarbari ... | Feb. 14-15 | 78 | - 4 | 2489 | + 3 | 912 | + 6 | 1655 | - 5 |
| | " 15-16 | 78 | 4 | 2487 | 5 | 903 | - 3 | 1663 | + 3 |
| | " 16-17 | 76 | 2 | 2497 | - 5 | 922 | + 16 | 1652 | - 8 |
| | " 17-18 | 78 | 4 | 2491 | + 1 | 909 | 3 | 1658 | 2 |
| Ranchandpur ... | Feb. 25-26 | 77 | - 3 | 2501 | - 9 | 895 | - 11 | 1684 | + 24 |
| | " 26-27 | 93 | 19 | 2497 | 5 | 941 | + 35 | 1650 | - 10 |
| | " 27-28 | 77 | 3 | 2490 | + 2 | 900 | - 6 | 1665 | + 5 |
| Siliguri ... | Mar. 12-13 | 66 | + 8 | 2495 | - 3 | 908 | + 2 | 1652 | - 8 |
| | " 13-14 | 72 | 2 | 2495 | 3 | 912 | 6 | 1656 | 4 |
| | " 14-15 | 77 | - 3 | 2492 | 0 | 909 | 3 | 1661 | + 1 |
| | " 15-16 | 67 | + 7 | 2512 | 20 | 919 | 13 | 1662 | 2 |
| Darjeeling ... | Mar. 20-21 | 75 | - 1 | 2482 | + 10 | + 900 | - 6 | 1658 | - 2 |
| | " 21-22 | 74 | 0 | 2491 | 1 | 903 | 3 | 1661 | + 1 |
| | " 22-23 | 71 | + 3 | 2494 | - 2 | 903 | + 2 | 1658 | - 2 |
| Kurseong ... | Mar. 27-28 | 74 | 0 | 2470 | + 22 | 898 | - 8 | 1644 | - 16 |
| | " 28-29 | 76 | - 2 | 2486 | 6 | 905 | 1 | 1655 | 5 |
| | " 29-30 | 67 | + 7 | 2489 | 3 | 905 | 1 | 1651 | 9 |
| | " 31-Apr. 1 | 73 | 1 | 2486 | 6 | 908 | + 2 | 1653 | 7 |
| Sandakphu ... | Ap. 10-11 | 71 | + 3 | 2481 | + 11 | 899 | - 7 | 1653 | - 7 |
| | " 11-12 | 70 | 4 | 2491 | 1 | 905 | 1 | 1656 | 4 |
| | " 12-13 | 65 | 9 | 2485 | 7 | 902 | 4 | 1649 | 11 |
| Dehra Dun Tent ... | May 12-13 | 67 | + 7 | 2491 | + 1 | 904 | - 2 | 1655 | - 5 |
| | " 13-14 | 72 | 2 | 2491 | 1 | 906 | 0 | 1656 | 4 |
| | " 14-15 | 78 | - 4 | 2488 | 4 | 901 | 5 | 1667 | + 7 |
| Dehra Dun Pendulum Room | May 17-18 | 72 | + 2 | 2491 | + 1 | 915 | + 9 | 1649 | - 11 |
| | " 18-19 | 70 | 4 | 2483 | 9 | 930 | 24 | 1622 | 38 |
| | " 19-20 | 72 | 2 | 2500 | - 8 | 918 | 12 | 1652 | 8 |
| Mean ... | ... | 74 | ... | 2492 | ... | 906 | ... | 1660 | ... |

In the above table the columns with the heading v contain the residuals when the mean of all the differences appertaining to each pendulum is subtracted from the individual values. On the whole it does not appear that Nos. 137 and 138 have changed their lengths; there is, it is true, a long series of positive residuals, from about the middle of March onwards, in the case of both these pendulums, but the amounts are not large and may either be accidental, or the reflex effect of a more important change in one of the other pendulums. No. 139 has a series of negatives at the beginning and three large positives at the end: the latter are, I am inclined to think, accidental and, by increasing the mean, they have been to some extent the cause of the negatives. In the case of No. 140 there is certainly evidence of a progressive change. The unbroken series of positives at the beginning, then the belt of uncertain sign extending from about January 20th to March 20th, followed by the series of negatives, seem to indicate a gradual increase in the time of vibration. The change in the residuals from November to May seems to have been about 18 (the value -38 on May 18th-19th is I think due to an accidental error). This being the effect of the real change on the difference between the mean pendulum and No. 140, the real change must be

$$\frac{4}{3} \times 18 = 24.$$

If this were the only evidence it would be justifiable to infer that the length of this pendulum had been changing and to assign an increasing value to the time of vibration at Dehra Dun which is employed in the deduction of g at the other stations; but in view of the fact that the observations in the tent at Dehra Dun in November and May do not show any noteworthy change, it would be impossible without inconsistency to adopt such a course and I have therefore in this as in the case of all the other pendulums accepted a simple mean.

We have therefore the following:—

Table IV.—Times of Vibration at Dehra Dún to be used in deducing g .

| | 137 | 138 | 139 | 140 | Mean |
|---------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Pendulum Room | 0 ^s ·5072590 | 0 ^s ·5075009 | 0 ^s ·5071606 | 0 ^s ·5070859 | 0 ^s ·5072516 |
| Tent | 0·5072580 | 0·5074992 | 0·5071602 | 0·5070810 | 0·5072504* |

Table V shews the times of vibration of each pendulum at the different stations and the difference between these times and those at Dehra Dun.

At the stations of Cuttack, Kesarbari, Ramchandpur, and Siliguri comparison has been made both with the values obtained in the pendulum room and with those in the tent; at Chatra and Kisanpur with the tent-values only, and at the remaining stations with the room-values only.

Table V. Times of Vibration and differences from Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|-----------------------------|--------------|--------------|--------------|--------------|--------------|
| Cuttack. | | | | | |
| Applying lag correction | | | | | |
| 1904 | ^s | ^s | ^s | ^s | ^s |
| December 12-13 | 0.5073636 | 0.5076045 | 0.5072654 | 0.5071897 | 0.5073558 |
| " 13-14 | 3618 | 6040 | 2649 | 1867 | 3544 |
| " 14-15 | 3636 | 6054 | 2661 | 1900 | 3563 |
| " 16-17 | 3637 | 6058 | 2659 | 1894 | 3562 |
| Means | 0.5073632 | 0.5076049 | 0.5072656 | 0.5071890 | 0.5073557 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 1042 | 1040 | 1050 | 1031 | 1041 |
| Not applying lag correction | | | | | |
| Means | 0.5073629 | 0.5076046 | 0.5072653 | 0.5071887 | 0.5073554 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 1049 | 1054 | 1051 | 1047 | 1050 |
| Chatra. | | | | | |
| 1904-05 | ^s | ^s | ^s | ^s | ^s |
| December 30-31 | 0.5073047 | 0.5075471 | 0.5072067 | 0.5071306 | 0.5072973 |
| " 31-Jan. 1 | 3060 | 5494 | 2083 | 1325 | 2991 |
| January 1-2 | 3052 | 5471 | 2095 | 1317 | 2984 |
| Means | 0.5073053 | 0.5075479 | 0.5072082 | 0.5071316 | 0.5072983 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 473 | 487 | 480 | 476 | 479 |
| Kisnapur. | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| January 17-18 | 0.5072859 | 0.5075275 | 0.5071877 | 0.5071112 | 0.5072781 |
| " 18-19 | 2847 | 5271 | 1867 | 1113 | 2775 |
| " 19-20 | 2855 | 5273 | 1885 | 1125 | 2785 |
| " 21-22 | 2833 | 5257 | 1856 | 1103 | 2762 |
| " 22-23 | 2870 | 5292 | 1887 | 1138 | 2797 |
| Means | 0.5072853 | 0.5075274 | 0.5071874 | 0.5071118 | 0.5072780 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 273 | 282 | 272 | 278 | 276 |
| Jalpaiguri. | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| January 31-Feb. 1 | 0.5072963 | 0.5075383 | 0.5071982 | 0.5071234 | 0.5072890 |
| February 1-2 | 2955 | 5373 | 1969 | 1221 | 2880 |
| " 2-3 | 2938 | 5368 | 1970 | 1212 | 2872 |
| Means | 0.5072952 | 0.5075375 | 0.5071974 | 0.5071222 | 0.5072881 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 362 | 366 | 368 | 363 | 365 |
| Kesarbari. | | | | | |
| Applying lag correction | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| February 14-15 | 0.5072834 | 0.5075245 | 0.5071844 | 0.5071101 | 0.5072756 |
| " 15-16 | 2868 | 5277 | 1887 | 1127 | 2790 |
| " 16-17 | 2887 | 5308 | 1889 | 1159 | 2811 |
| " 17-18 | 2919 | 5332 | 1932 | 1183 | 2841 |
| Means | 0.5072877 | 0.5075291 | 0.5071888 | 0.5071143 | 0.5072799 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 287 | 282 | 282 | 284 | 283 |
| Not applying lag correction | | | | | |
| Means | 0.5072872 | 0.5075286 | 0.5071883 | 0.5071138 | 0.5072794 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 292 | 294 | 281 | 298 | 290 |

Table V. Times of Vibration and differences from Dehra Dún—(Continued).

| Date | 137 | 138 | 139 | 140 | Mean |
|-----------------------------|--------------|--------------|--------------|--------------|--------------|
| Ramchandpur. | | | | | |
| Applying lag correction | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| February 25-26 | 0.5072846 | 0.5075270 | 0.5071874 | 0.5071085 | 0.5072769 |
| " 26-27 | 2827 | 5231 | 1793 | 1084 | 2734 |
| " 27-28 | 2846 | 5259 | 1869 | 1104 | 2769 |
| Means | 0.5072840 | 0.5075253 | 0.5071845 | 0.5071091 | 0.5072757 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 250 | 244 | 239 | 232 | 241 |
| Not applying lag correction | | | | | |
| Means | 0.5072837 | 0.5075250 | 0.5071842 | 0.5071088 | 0.5072754 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 257 | 258 | 240 | 248 | 250 |
| Siliguri. | | | | | |
| Applying lag correction | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| March 12-13 | 0.5073029 | 0.5075458 | 0.5072055 | 0.5071311 | 0.5072963 |
| " 13-14 | 3042 | 5465 | 2058 | 1314 | 2970 |
| " 14-15 | 3058 | 5473 | 2072 | 1320 | 2981 |
| " 15-16 | 3027 | 5472 | 2041 | 1298 | 2960 |
| Means | 0.5073039 | 0.5075467 | 0.5072057 | 0.5071311 | 0.5072969 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 449 | 458 | 451 | 452 | 453 |
| Not applying lag correction | | | | | |
| Means | 0.5073035 | 0.5075463 | 0.5072052 | 0.5071307 | 0.5072964 |
| Dehra Tent | 0.5072580 | 0.5074992 | 0.5071602 | 0.5070840 | 0.5072504 |
| Difference | 455 | 471 | 450 | 467 | 460 |
| Darjeeling. | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| March 20-21 | 0.5074049 | 0.5076456 | 0.5073074 | 0.5072316 | 0.5073974 |
| " 21-22 | 4045 | 6462 | 3068 | 2310 | 3971 |
| " 22-23 | 4045 | 6468 | 3066 | 2316 | 3974 |
| Means | 0.5074046 | 0.5076462 | 0.5073069 | 0.5072314 | 0.5073973 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 1456 | 1453 | 1463 | 1455 | 1457 |
| Kurseong. | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| March 27-28 | 0.5073715 | 0.5076111 | 0.5072743 | 0.5071997 | 0.5073641 |
| " 28-29 | 3722 | 6132 | 2741 | 1991 | 3646 |
| " 29-30 | 3725 | 6147 | 2753 | 2007 | 3658 |
| " 31-Apr. 1 | 3719 | 6132 | 2738 | 1993 | 3646 |
| Means | 0.5073720 | 0.5076131 | 0.5072744 | 0.5071997 | 0.5073648 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 1130 | 1122 | 1138 | 1138 | 1132 |
| Sandakphu. | | | | | |
| 1905 | ^s | ^s | ^s | ^s | ^s |
| April 10-11 | 0.5074847 | 0.5077257 | 0.5073877 | 0.5073123 | 0.5074776 |
| " 11-12 | 4849 | 7270 | 3874 | 3123 | 4779 |
| " 12-13 | 4843 | 7263 | 3876 | 3129 | 4778 |
| Means | 0.5074846 | 0.5077263 | 0.5073876 | 0.5073125 | 0.5074778 |
| Dehra Pendulum Room | 0.5072590 | 0.5075009 | 0.5071606 | 0.5070859 | 0.5072516 |
| Difference | 2256 | 2254 | 2270 | 2266 | 2262 |

The values of g derived from the differences in Table V are shewn in Table VI; g at Dehra Dún being taken to be 979·063.

Table VI. Deduced Values of g .

| | | 137 | 138 | 139 | 140 | Mean |
|-------------|------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Cuttack | (1) (2) | 978·661 ·658 | 978·661 ·656 | 978·658 ·657 | 978·665 ·659 | 978·661 ·658 |
| Chatra | ... | 978·880 | 978·875 | 978·878 | 978·879 | 978·878 |
| Kisnapur | ... | 978·958 | 978·954 | 978·958 | 978·956 | 978·956 |
| Jalpaiguri | ... | 978·924 | 978·922 | 978·921 | 978·923 | 978·922 |
| Kesarbari | (1) (2) | 978·952 ·951 | 978·954 ·950 | 978·954 ·955 | 978·953 ·948 | 978·953 ·951 |
| Ramchandpur | (1) (2) | 978·967 ·964 | 978·969 ·963 | 978·971 ·970 | 978·973 ·967 | 978·970 ·966 |
| Siliguri | (1) (2) | 978·890 ·887 | 978·886 ·881 | 978·889 ·889 | 978·888 ·883 | 978·888 ·885 |
| Darjeeling | ... | 978·501 | 978·502 | 978·498 | 978·501 | 978·501 |
| Kurseong | ... | 978·626 | 978·630 | 978·624 | 978·624 | 978·626 |
| Sandakphu | ... | 978·192 | 978·193 | 978·187 | 978·188 | 978·190 |

Reduction to Sea-level.

The computation of the orographical correction was carried out in the same way as before, but the regions surrounding the stations were not analysed so minutely.

The Nepal frontier lies but a short distance to the west of the hill stations visited this year, and as there are no trustworthy maps of that country a detailed examination would have been unprofitable.

The stations which came under consideration were Jalpaiguri, Siliguri, Kurseong, Darjeeling and Sandakphu; I was in doubt as to whether a correction would be required at Jalpaiguri. The distance of this place from the foot hills is about 28 miles, that of Siliguri is about 8 miles; I decided to compute the corrections for the latter first and so obtain some idea of the magnitude of the attraction exercised by the hills on places not far from their foot.

In the tables that follow I have not thought it necessary to give so much detail as was done in the case of Mussooree.

Table VII. Orographical corrections at Siliguri.

Height 387 feet.

| r_1 r_2 | 7½ miles 10 " | 10 miles 12½ " | 12½ miles 15 " | 15 miles 20 " | 20 miles 25 " | 25 miles 30 " | 30 miles 35 " |
|----------------|------------------|-------------------|-------------------|------------------|------------------|------------------|------------------|
| Azimuth from N | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> |
| 0-15 | 100 | 1100 | 1600 | 1600 | 1600 | 2600 | 3600 |
| 15-30 | 100 | 200 | 400 | 2100 | 3600 | 3600 | 3600 |
| 30-45 | 0 | 100 | 200 | 1600 | 1600 | 2100 | 5600 |
| 45-60 | 0 | 0 | 100 | 300 | 400 | 600 | 1100 |
| 60-75 | 0 | 0 | 0 | 100 | 100 | 100 | 200 |
| 75-90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90-270 | Southern | Compartments | all at the | same level | as the | station | |
| 270-285 | 0 | 0 | 0 | 400 | 600 | 600 | 1600 |
| 285-300 | 0 | 100 | 300 | 1100 | 2600 | 3600 | 3600 |
| 300-315 | 100 | 200 | 1100 | 2600 | 3600 | 2600 | 4600 |
| 315-330 | 200 | 600 | 2600 | 2600 | 3600 | 4600 | 6600 |
| 330-345 | 300 | 1600 | 2600 | 4600 | 5600 | 3600 | 4600 |
| 345-360 | 300 | 2100 | 2600 | 2600 | 2600 | 2100 | 3600 |
| Effect ... | 0.03 | 0.68 | 1.26 | 3.51 | 3.54 | 2.29 | 2.73 |

Total effect of zones within 35 miles radius = 14.04

Attraction ... = 14.04×0.000035
= 0.00049

From this result it may be inferred that at Jalpaiguri the effect of the hills up to a radius of 35 miles will be entirely negligible.

Not far beyond the 35 miles radius in the case of Siliguri, and of a 60-mile radius in the case of Jalpaiguri, lie the giant mountains of the Kinchinjunga group, and beyond that again are the highlands of Tibet. We may take account of them by assuming that in the case of Siliguri one-third of the region outside the 35-mile circle is occupied by a table-land 7000 feet high, and that the same is true of Jalpaiguri outside the 60-mile radius. 7000 feet is undoubtedly too low for the Tibetan plateau, 12000 feet would be nearer the truth, but for the Himalayan region, where deep valleys alternate with high peaks, 7000 feet is probably a sufficient estimate even among the high ranges, and among the outer hills it is too great, so that on the whole, considering the greater proximity of the smaller ranges, this average height may be accepted.

Table IX. Orographical Correction at Kurseong.

Height 4913 feet.

Zones from 3 to 35 miles.

| No. of Zone | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|----------------|----------------|----------------|----------------|------------------------------|-------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| r_1 r_2 | 3 miles 4 " | 4 miles 5 " | 5 miles 6 " | 6 miles 7 $\frac{1}{2}$ " | 7 $\frac{1}{2}$ miles 10 " | 10 miles 12 " | 12 miles 16 " | 16 miles 20 " | 20 miles 25 " | 25 miles 30 " | 30 miles 35 " |
| | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet |
| | 400 | 900 | 2200 | 2600 | 2200 | 900 | 1700 | 2400 | 400 | 1600 | 2100 |
| | 900 | 2100 | 1800 | 1400 | 900 | 600 | 1700 | 2400 | 900 | 1600 | 1600 |
| | 1500 | 1300 | 600 | 700 | 1500 | 2900 | 3400 | 2900 | 2400 | 900 | 600 |
| | 600 | 500 | 600 | 2200 | 2600 | 3400 | 3400 | 2400 | 1200 | 1100 | 1300 |
| | 1600 | 900 | 900 | 900 | 1400 | 2900 | 1900 | 1600 | 1400 | 1400 | 1600 |
| | 2500 | 2600 | 2800 | 2100 | 2600 | 2900 | 3400 | 2400 | 2900 | 3400 | 3400 |
| | 2600 | 3600 | 3600 | 3200 | 3100 | 3900 | 4100 | 4100 | 4100 | 4100 | 4100 |
| | 2700 | 3200 | 3400 | 3700 | 3700 | 3900 | 4300 | 4500 | 4300 | 4400 | 4500 |
| | 2000 | 2900 | 3500 | 4000 | 4400 | 4400 | 4500 | 4600 | 4500 | 4600 | 4600 |
| | 2800 | 3500 | 3800 | 4200 | 4400 | 4500 | 4600 | 4600 | 4600 | 4600 | 4600 |
| | 3500 | 3700 | 4100 | 4200 | 4500 | 4500 | 4600 | 4600 | 4600 | 4600 | 4600 |
| | 3500 | 3900 | 4100 | 4400 | 4500 | 4500 | 4600 | 4600 | 4600 | 4600 | 4600 |
| | 3300 | 3700 | 4000 | 4400 | 4500 | 4500 | 4600 | 4600 | 4600 | 4600 | 4600 |
| | 3000 | 3800 | 3700 | 4000 | 4400 | 4500 | 4600 | 4600 | 4600 | 4600 | 4600 |
| | 3200 | 3300 | 3300 | 3500 | 4300 | 4500 | 4500 | 4600 | 4600 | 4600 | 4600 |
| | 2900 | 2100 | 2100 | 2700 | 3600 | 3900 | 4100 | 4600 | 4600 | 4500 | 4500 |
| | 2500 | 1700 | 1100 | 2400 | 2700 | 2900 | 3400 | 3900 | 3900 | 3900 | 3400 |
| | 2400 | 1200 | 700 | 1400 | 900 | 2400 | 1900 | 2900 | 2400 | 3400 | 2400 |
| | 1900 | 700 | 300 | 200 | 600 | 1900 | 1900 | 1900 | 900 | 1900 | 1400 |
| | 2200 | 1900 | 1400 | 900 | 400 | 100 | 900 | 100 | 100 | 1100 | 100 |
| | 2200 | 1600 | 1100 | 400 | 300 | 1100 | 100 | 2600 | 3100 | 3100 | 100 |
| | 1500 | 1600 | 1700 | 1200 | 600 | 1100 | 2000 | 2100 | 4100 | 4100 | 2100 |
| | 900 | 300 | 700 | 600 | 1400 | 900 | 1400 | 1100 | 2100 | 2600 | 4100 |
| | 300 | 300 | 800 | 1100 | 2100 | 900 | 1700 | 2400 | 1100 | 1600 | 2100 |
| Effect ... | 42.6 | 28.6 | 20.4 | 23.5 | 28.5 | 16.5 | 24.6 | 14.7 | 10.9 | 8.1 | 4.3 |

Total effect of zones within 35 miles radius = 481.2

Attraction = 481.2 \times 0.000035
= 0.0168

For the country lying outside the 35-mile radius we may, at Kurseong, make the same assumption as was made for Mussooree, namely, that the southern half is at sea-level and that the northern half consists of an elevated plain. In the case of Mussooree I assumed this plain to be at the same height as the station, here I shall assume it to be 2,000 feet higher than the station. Thus to complete the orographical correction we require the effect of half the infinite plain outside the 35-mile radius + the effect of a half zone 2,000 feet thick of which the inner radius is 35 miles and the outer infinite.

| | |
|---|-------------------|
| Attraction of infinite plain | = 0.1720 |
| „ „ plain of 35-mile radius | = <u>0.1696</u> |
| Difference | = 0.0024 |
| Half difference | = 0.0012 |
| Attraction of half zone 2000 feet thick | = 0.00019 |
| Quantity required to complete orographical correction | = 0.0014 |
| Total orographical correction | = 0.0168 + 0.0014 |
| | = 0.0182 |

Table X. Orographical Correction at Darjeeling.

Height 6966 feet.

(Zones up to 6 miles).

[illegible]

Table XI. Orographical Correction at Darjeeling.

Height 6966 feet.

(Zones from 6 to 35 miles).

| No. of Zone | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|----------------|-----------------|------------------|-------------------|-------------------|------------------|------------------|------------------|------------------|
| r_1 r_2 | 6 miles 7½ " | 7½ miles 10 " | 10 miles 12½ " | 12½ miles 15 " | 15 miles 20 " | 20 miles 25 " | 25 miles 30 " | 30 miles 35 " |
| | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> | <i>feet</i> |
| | 5000 | 2500 | 1500 | 2000 | 2000 | 1500 | 2000 | 6000 |
| | 4500 | 1800 | 1500 | 700 | 500 | 1200 | 2000 | 5000 |
| | 4500 | 2500 | 1000 | 700 | 2000 | 1500 | 1000 | 1000 |
| | 5500 | 5000 | 3000 | 2500 | 3500 | 1000 | 500 | 2000 |
| | 5200 | 5500 | 4500 | 5000 | 5000 | 3000 | 2500 | 1500 |
| | 2500 | 5000 | 5500 | 4000 | 3000 | 2000 | 3000 | 1500 |
| | 2700 | 5500 | 5000 | 5800 | 3500 | 4500 | 4500 | 5000 |
| | 4100 | 5500 | 6000 | 5500 | 4000 | 5500 | 6300 | 6400 |
| | 3500 | 4500 | 5000 | 5800 | 6000 | 6500 | 6600 | 6700 |
| | 1700 | 3000 | 3500 | 4000 | 6500 | 6600 | 6700 | 6700 |
| | 800 | 1500 | 4000 | 5000 | 6500 | 6600 | 6700 | 6700 |
| | 1000 | 2500 | 2000 | 4500 | 6300 | 6600 | 6700 | 6700 |
| | 1900 | 3500 | 3500 | 4500 | 5500 | 6600 | 6700 | 6700 |
| | 3300 | 3000 | 3000 | 4000 | 5500 | 6200 | 6700 | 6700 |
| | 3200 | 2000 | 3000 | 4000 | 5000 | 5500 | 6600 | 6500 |
| | 1700 | 1000 | 2000 | 3000 | 3000 | 4000 | 5500 | 6000 |
| | 900 | 1000 | 2000 | 2000 | 3000 | 3000 | 4500 | 5000 |
| | 2700 | 2000 | 1500 | 1500 | 1000 | 1000 | 1000 | 2000 |
| | 2500 | 800 | 1500 | 1500 | 2000 | 1000 | 1000 | 3000 |
| | 2700 | 1000 | 1000 | 1500 | 2500 | 1000 | 1000 | 1000 |
| | 2700 | 2000 | 2000 | 1000 | 2500 | 2000 | 1000 | 1000 |
| | 3800 | 2500 | 1800 | 1500 | 2000 | 2500 | 2000 | 4000 |
| | 4500 | 1800 | 1000 | 1000 | 2000 | 2000 | 4000 | 5000 |
| | 4000 | 1500 | 1000 | 500 | 800 | 1000 | 4000 | 6000 |
| Effect | 36.1 | 32.6 | 18.6 | 14.7 | 24.8 | 15.7 | 13.4 | 9.5 |

Total effect of zones within 35-mile radius = 680.5

Attraction = 680.5 \times 0.000035 = 0.0238

At Darjeeling the assumption that was made for Mussooree and Kurseong, is not applicable; for this station lies further in among the hills. But the effect of the zones beyond the 35-mile radius may be estimated in another way. As we extend the radii, the character of the compartments of which the zones are composed will not change much; the southern halves of the zones will lie almost wholly in the plains, the northern compartments among the higher ranges and the eastern and western among the outer hills, thus there will be no great change in the effect of the zones because of changes in the heights of their compartments, and there will be a continual decrease owing to the increasing distance from the station. This decrease is proportional to the decrease in the difference between the reciprocals of the radii. If we make this difference constant and equal to its value for the 30-35-mile zone, we find the following radii 42, 53, 70, 105, 210, 100000, we may therefore take it that the masses which lie beyond the 35-mile radius will have an effect equivalent to six times that of the 30-35-mile zone. The effect of this zone was 9.5, so that 57.0 is to be added for the outer regions. The addition to the orographical correction is therefore

$$57.0 \times 0.000035 = 0.0020$$

and the total correction is $0.0238 + 0.0020$
 $= 0.0258$

Table XII. Orographical Correction at Sandakphu.

Height 11766 feet.

(Zones up to 4 miles).

[illegible]

Table XIII. Orographical Correction at Sandakphu.

Height 11766 feet.

(Zones from 4 to 35 miles).

| No. of Zone | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|-------------|---|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| r_1 | 4 miles | 5 miles | 6 miles | 7½ miles | 10 miles | 12 miles | 16 miles | 20 miles | 25 miles | 30 miles |
| r_2 | 5 " | 6 " | 7½ " | 10 " | 12 " | 16 " | 20 " | 25 " | 30 " | 35 " |
| | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh | Δh |
| N | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet |
| | 1000 | 1300 | 1000 | 800 | 1800 | 2800 | 1800 | 1200 | 3200 | 5200 |
| | 600 | 1400 | 2000 | 2800 | 3800 | 3800 | 2800 | 1800 | 700 | 2200 |
| | 2100 | 2100 | 3000 | 2300 | 4800 | 3800 | 5800 | 4800 | 2800 | 2200 |
| E | 3100 | 3700 | 4800 | 2800 | 3800 | 4800 | 5800 | 6800 | 4800 | 1800 |
| | 5000 | 5400 | 5800 | 4800 | 5800 | 8800 | 7800 | 6800 | 5800 | 6800 |
| | 3200 | 4400 | 6000 | 6800 | 7800 | 8800 | 8800 | 8800 | 7800 | 8800 |
| | 4000 | 5600 | 6300 | 6300 | 6800 | 7800 | 6800 | 9300 | 9800 | 9800 |
| S | 5200 | 6000 | 4600 | 5300 | 7800 | 5800 | 5800 | 5800 | 8800 | 10300 |
| | 4800 | 3900 | 3100 | 5100 | 6800 | 5800 | 7800 | 6800 | 9300 | 11100 |
| | 3700 | 3300 | 2400 | 4300 | 5800 | 5800 | 7800 | 8800 | 10800 | 11400 |
| | 2900 | 2800 | 3800 | 4800 | 6800 | 6800 | 8800 | 10800 | 11200 | 11500 |
| W | 4300 | 3800 | 4300 | 5800 | 7800 | 7800 | 9800 | 10600 | 11500 | 11500 |
| | No map available for the western halves of these zones. It has been assumed that they are the same as the eastern halves. | | 5800 | 6800 | 8800 | 8800 | 9800 | 10300 | 11400 | 11500 |
| | | | 6800 | 5800 | 8800 | 9800 | 9800 | 10800 | 10800 | 10800 |
| | | | 5800 | 6800 | 8800 | 8800 | 9300 | 9800 | 10300 | 10800 |
| | | | 5800 | 6800 | 7800 | 6800 | 8800 | 7800 | 7800 | 8800 |
| | | | 6800 | 4800 | 6800 | 5800 | 7800 | 6800 | 7800 | 7800 |
| | | | 4800 | 3800 | 6800 | 6800 | 7800 | 8800 | 8800 | 9800 |
| | | | 5800 | 5800 | 6800 | 7800 | 8800 | 8800 | 7800 | 5800 |
| | | | 4800 | 4800 | 5800 | 7800 | 8800 | 7800 | 7800 | 4800 |
| | | | 5800 | 5800 | 5800 | 5800 | 7800 | 6800 | 7800 | 6800 |
| | | | 5800 | 5800 | 5800 | 4800 | 7800 | 6800 | 5800 | 3800 |
| | | | 4800 | 4800 | 3800 | 5800 | 5800 | 5800 | 2800 | 6800 |
| 2800 | | | 2800 | 3800 | 6800 | 5800 | 6800 | 4800 | 5800 | |
| Effect | 62.1 | 48.4 | 76.4 | 83.8 | 67.5 | 88.3 | 72.5 | 58.6 | 43.4 | 26.5 |

Total effect of zones within 35-mile radius = 1343.9

Attraction = $1343.9 \times 0.000035 = 0.0470$

At Sandakphu the outer zones may be treated in the same way as at Darjeeling.

The effect of the 30-35-mile zone was 26.5, hence that of the remainder may be estimated at $26.5 \times 6 = 159.0$, and the addition to the orographical correction is

$$159.0 \times 0.000035 = 0.0056$$

$$\begin{aligned} \text{The total correction therefore} &= 0.0470 + 0.0056 \\ &= 0.0526 \end{aligned}$$

The results of the season's work are summarised in Table XIV. In the case of stations at which the times of vibration are given in Table V both with and without a lag correction, the mean of the two values at Dehra Dún, that is to say in the room and in the tent respectively, and the mean of the differences, have been used in computing g . The formula employed was

$$g = g_0 - 2g_0 \frac{s-s_0}{s_0} + 3g_0 \left(\frac{s-s_0}{s_0} \right)^2$$

where the letters with the subscript 'o' refer to Dehra Dún.

The third term of the formula has not been used except in the case of Sandakphu.

When $s-s_0 = 2090 \times 10^{-7}$, the value of this term = 0.0005.

For g_0 the same value as before, namely 979.063 has been adopted.

Table XIV. Abstract of final Results.

| Station | Latitude | Height | Observed g | $g \frac{2h}{R}$ | $g \frac{3h}{4R}$ | O | Value at sea level g_0'' | γ_0 | $g_0'' - \gamma_0$ |
|-------------|----------|--------|-----------------|------------------|-------------------|--------|----------------------------------|------------|--------------------|
| Cuttack | 20 29 | 92 | 978.659 | +0.009 | -0.003 | 0.000 | 978.665 | 978.636 | +0.029 |
| Chatra | 24 13 | 64 | 978.878 | +0.006 | -0.002 | 0.000 | 978.882 | 978.873 | +0.009 |
| Kisnapur | 25 2 | 113 | 978.956 | +0.011 | -0.004 | 0.000 | 978.963 | 978.930 | +0.033 |
| Ramchandpur | 25 41 | 132 | 978.968 | +0.013 | -0.005 | 0.000 | 978.976 | 978.975 | +0.001 |
| Kesarbari | 26 8 | 204 | 978.952 | +0.019 | -0.007 | 0.000 | 978.964 | 979.007 | -0.043 |
| Jalpaiguri | 26 31 | 268 | 978.922 | +0.025 | -0.009 | +0.001 | 978.939 | 979.035 | -0.096 |
| Siliguri | 26 42 | 387 | 978.887 | +0.036 | -0.014 | +0.002 | 978.911 | 979.048 | -0.137 |
| Kurseong | 26 53 | 4913 | 978.626 | +0.460 | -0.172 | +0.018 | 978.932 | 979.062 | -0.130 |
| Darjeeling | 27 3 | 6966 | 978.501 | +0.646 | -0.242 | +0.026 | 978.931 | 979.074 | -0.143 |
| Sandakphu | 27 6 | 11766 | 978.190 | +1.096 | -0.411 | +0.053 | 978.928 | 979.078 | -0.150 |

Professor Dr. Hecker has been so kind as to furnish me with the full details of his observations at Jalpaiguri, but as they will appear in the publications of the Prussian Geodetic Institute it will be sufficient for me to give a summary of them here. He was equipped with a set of six pendulums namely Nos. 5, 6, 7, 8, 16 and 21, but No. 6 has not been utilised in the determination of g^* .

The times of vibration of the 5 pendulums at Potsdam before and after his journey were :—

| Pendulum | 5 | 7 | 8 | 16 | 21 | Mean |
|------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Before ... | $^s 0.5083411$ | $^s 0.5083150$ | $^s 0.5083166$ | $^s 0.5076739$ | $^s 0.5097473$ | $^s 0.5084788$ |
| After ... | $^s 0.5083413$ | $^s 0.5083138$ | $^s 0.5083143$ | $^s 0.5076740$ | $^s 0.5097472$ | $^s 0.5084781$ |
| Mean ... | $^s 0.5083412$ | $^s 0.5083144$ | $^s 0.5083155$ | $^s 0.5076740$ | $^s 0.5097473$ | $^s 0.5084785$ |

At Jalpaiguri Dr. Hecker observed each pendulum six times obtaining the following values :—

| Pendulum | 5 | 7 | 8 | 16 | 21 | Mean |
|-------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | $^s 0.5089497$ | $^s 0.5089250$ | $^s 0.5089278$ | $^s 0.5082828$ | $^s 0.5103598$ | $^s 0.5090890$ |
| | 519 | 241 | 264 | 830 | 613 | 93 |
| | 494 | 244 | 242 | 820 | 587 | 77 |
| | 501 | 240 | 246 | 821 | 590 | 80 |
| | 512 | 229 | 239 | 827 | 596 | 81 |
| | 504 | 233 | 244 | 826 | 591 | 80 |
| Mean ... | $^s 0.5089505$ | $^s 0.5089240$ | $^s 0.5089252$ | $^s 0.5082825$ | $^s 0.5103596$ | $^s 0.5090884$ |
| Difference from Potsdam | 6093 | 6096 | 6097 | 6085 | 6123 | 6099 |

The resulting values of g at Jalpaiguri are :—

| Pendulum | 5 | 7 | 8 | 16 | 21 |
|--------------|---------|---------|---------|---------|---------|
| g | 978.926 | 978.925 | 978.924 | 978.926 | 978.921 |
| Mean 978.924 | | | | | |

My value (vide table XIV) is 978.922 and the agreement between the two results is extremely satisfactory.

My value of g at Jalpaiguri is obtained by three steps namely :—

$$g \text{ at Potsdam} \quad \dots \quad = \quad 981.274$$

1. g at Kew less than g at Potsdam by 0.074

$$(\text{Mr. Putnam's determination in 1900}) \quad = \quad 981.200$$

* I am not aware of the reason for omitting the result by No. 6.

2. g at Dehra Dún less than g at Kew by 2·137

$$(\text{observations of 1903-04}) = 979\cdot063$$

3. g at Jalpaiguri less than g at Dehra by 0·141

$$(\text{observations of 1904-05}) = 978\cdot922$$

The agreement therefore of Dr. Hecker's result with mine makes it probable that there is no error of importance in any of the above steps. This is the more satisfactory as the Dehra Dún observations of 1904-05 were not by any means as accordant as could be wished.

It is still desirable that the connection between Kew and Dehra be strengthened when an opportunity occurs, but in the mean time we may feel tolerably confident that the value 979·063 which has been adopted for Dehra Dún is not far from the truth.

CHAPTER IV.

The Observations in 1905-06.

For the scene of the operations in 1905-06 Colonel Burrard selected a line running, roughly speaking, from Simla to Quetta. The objects in view were:—

(1) To ascertain whether the marked deficiencies in the force of gravity, which had been observed in the outer Himalayan Range, and in the submontane tracts, both on the meridian of Dehra Dún and on that of Darjeeling, would again be found in the neighbourhood of Simla.

(2) To see whether the pendulums would throw light on the deflections of the Plumb-line indicated by the Amritsar—Multán arc of longitude. On this arc one would have expected to find the Plumb-lines at both ends deflected outwards, towards the Himalayas and the Suleman mountains respectively, but it was found on the contrary that they were deflected inwards.

(3) To make a first step towards the examination of the Baluchistan mountains.

(4) To make a set of observations at Captain Basevi's station at Mián Mir. This was the last station at which Basevi observed before starting on his journey to Moré, and at it the pendulums were swung on a stand which had been specially constructed for that difficult expedition. It has been thought that this stand may have been less rigid than the ordinary one, and that therefore the observations at Mián Mir and Moré may require a specially large correction for flexure.

The observations of the previous season had shewn that the variations of temperature in a tent are too large; it was decided therefore to visit during this season only places in which suitable houses were available. Through the kind assistance of the officers of the P. W. Department, of the Indian Civil Service and the Military Works Service, good observing rooms were obtained at all the stations visited.

The equipment was the same as before except that the Transit Instrument No. 1 was used instead of No. 2. No. 1 had been fitted with a glass diaphragm with lines ruled upon it instead of the spider webs hitherto employed. There had been a good deal of trouble with the webs owing to their breaking or becoming loose, and I therefore determined to try lines on glass. The diaphragm was made and fitted by Messrs. Troughton and Simms. It is certainly very much more convenient than the webs and I donot think that there has been any falling off in the accuracy of the intersections.

An improvement was introduced this year in the method of observing the star-transits. Hitherto it has been the custom to divide the programme of stars into two parts and to observe the one in the position I. P. E.* and the other in the position I. P. W. This year the plan was adopted of reversing the telescope in the middle of the observation of each star, this cancels collimation error, error due to inequality of pivots and error due to imperfect knowledge of the

* Illuminated pivot east.

wire-intervals. Furthermore the reduction of the observations is much abbreviated, for the process of reducing to the centre wire is got rid of, without losing the check on the accuracy of the intersections afforded by a comparison of the times of transit over each wire.

Throughout the season the time observations were undertaken by Babu Hanuman Prasad.

The same set of thermometers was used this year as last. During the summer three of them, namely Nos. 105368 and 105369 by Negretti and Zambra and No. 516 by Fuess had been sent to the National Physical Laboratory for a redetermination of their errors. The results agreed well with those of the determination made in Nov. 1903.

A dummy pendulum, with a hollow stem for the reception of a thermometer, was also made for me during the summer by the Mathematical Instrument Department.

A dummy pendulum for the thermometers intended to give the temperature of the true pendulum was included in the equipment used by Captain Basevi*, and so far as I am aware, one has always formed part of the Von Sterneck apparatus. A device of this kind is specially necessary when the temperature is unsteady, and I regretted that I was not equipped with one when observing in the tent. Dr. Hecker had one with him and the one made for me is a copy of his.

I took the dummy pendulum into use at Dehra Dún at the beginning of the field season, and the results it gave seemed quite satisfactory, but after that I found that whether the temperature of the air was rising or falling the reading of the thermometer in the dummy was always considerably below that of the other thermometers; the reason I at last found to be that there was too much connection between the dummy and the masonry pillar. The latter at all the stations except Dehra Dún had been but recently built, and was damp and colder than the surrounding air, and the dummy was constantly parting with its heat to the stone cap through the little tripod on which it stood. I could not alter the state of things during the tour and I therefore used the readings of the two thermometers attached to the stand for the reduction of the observations, as on former occasions.

The masonry pillar for the pendulum stand was of the same pattern and dimensions as before.

The temperature conditions were fairly satisfactory at all the stations visited, and as there was but little difference between them and those that obtained at Dehra Dún, no lag corrections have been applied. The rate of change of the temperature is shewn in the table giving the details of the observations, whence it may be seen that the corrections if computed would have been of nearly equal magnitude throughout, and therefore without effect on the differences from Dehra Dún.

The latitudes and longitudes have all been taken off the 1-inch or 2-inch map, whichever was available, except in one or two cases which are mentioned in the descriptions of the stations. The way in which the height of each station was derived is also mentioned in the description.

The longitudes have all received the correction necessary to reduce them to the most recent terms, namely those in which the longitude of Madras has the value $80^{\circ} 14' 54''$.

* *Vide* Vol. V *Op. G. T. S.* Chapter II, Para 5.

THE STATIONS.

Dehra Dun.

| | | | | | |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 19 | 29 |
| Longitude | ... | ... | 78 | 3 | 22 |
| Height above mean sea level | ... | | | | 2241 feet |

The observations were made in the new pendulum room. None were taken in the tent.

The flexure correction was observed four times:—

| | |
|-----------------------|-----------------------|
| 12th November | 15th November |
| 42.5×10^{-7} | 42.9×10^{-7} |
| 42.5 | 42.3 |

Adopted Correction $- 43 \times 10^{-7}$

Simla.

| | | | | | |
|-----------------------------|-----|-----|----|---|-----------|
| Latitude | ... | ... | 31 | 6 | 19 |
| Longitude | ... | ... | 77 | 9 | 50 |
| Height above mean sea level | ... | | | | 7043 feet |

The pendulum station was situated in one of the rooms on the N. W. side of the civil secretariat (Gorton Castle). The height was determined by levelling from the P. W. D. h. s. of the Simla triangulation.

The floor of the room was good and an isolated foundation for the pendulum pedestal was not provided.

The temperature conditions were good. The observations were much delayed by cloudy weather; the apparatus was ready on the 12th December but no stars were obtained till the 15th.

The flexure correction was determined five times, but only the last three observations have been used as the other two were made on the 12th.

The results were:—

| | |
|-----------------------|-----------------------|
| 14th December | 19th December |
| 34.7×10^{-7} | 35.1×10^{-7} |
| | 34.4 |

Adopted Correction $- 35 \times 10^{-7}$

Kalka.

| | | | | | |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 50 | 8 |
| Longitude | ... | ... | 76 | 56 | 22 |
| Height above mean sea level | ... | | | | 2202 feet |

The pendulum station was situated in the last room but one from the east end of the long single-storied building known as Lowrie's hotel.

To ascertain the height a line of levels was run from rail-level at the railway station to the floor of the room, showing that the latter is 55 feet higher than the former. Rail-level at

Kálka is 1251 feet above rail-level at Ambála, and rail-level at Ambála was found, by running a line to the G. T. bench-mark on the steps of the church, to be 896 feet above mean sea level.

Only one set of observations was made at this station.

The flexure correction was determined four times :—

| | 22nd December | 23rd December |
|--------------------|---------------------------------------|---------------------------------------|
| | ^s 41.5×10^{-7} | ^s 40.8×10^{-7} |
| | 40.2 | 43.4 |
| Adopted Correction | ^s -42×10^{-7} | |

Ludhiana.

| | ° | ' | " |
|---------------------------------|-----------|----|----|
| Latitude ... | 30 | 55 | 25 |
| Longitude ... | 75 | 51 | 9 |
| Height above mean sea-level ... | 835 feet. | | |

The pendulum station was situated in the western room of the ground floor of the two-storied block of officers' quarters in Ludhiána fort. The room has thick walls and a vaulted roof, and the temperature conditions were good. Isolated platforms were built for the pendulum pedestal and for the clock.

The height was determined by running a line of levels from the centre of the metalling at the junction of the Ambála and Ferozepore roads. It was assumed that this point was 2 feet higher than the imbedded bench-mark of the G. T. levels mentioned on p. 107 of the pamphlet of 1863. This bench-mark could not be found.

The flexure correction was determined five times :—

| | 30th December | 5th January |
|--------------------|---------------------------------------|---------------------------------------|
| | ^s 43.5×10^{-7} | ^s 43.6×10^{-7} |
| | 43.8 | 40.7 |
| | | 41.4 |
| Adopted Correction | ^s -43×10^{-7} | |

At this station the method of reversing the transit instrument in the middle of the observation of each star, was used for the first time.

Mian Mir.

| | ° | ' | " |
|---------------------------------|-----------|----|----|
| Latitude ... | 31 | 31 | 37 |
| Longitude ... | 74 | 22 | 32 |
| Height above mean sea level ... | 708 feet. | | |

The pendulum station was situated in the southernmost of the three principal rooms of a small bungalow which stands immediately behind (*i. e.* to the west of) Messrs. Jamsetjee's shop, and a little to the east of north of the racket court.

This is probably not the same house as that in which Captain Basevi observed in 1871. Enquiries from old residents shewed that there had been a small house about 100 yards further west, which had been pulled down some time ago, it seems probable that it was there that the old pendulum observations were made.

The height was determined by a line of levels from a G. T. bench-mark on the steps of the church.

The longitude given by Captain Basevi for his station is $74^{\circ} 25' 40''$, that which I found for my station by a traverse to the church, the co-ordinates of the steeple of which are given in Synoptical Volume IV of the G. T. Survey, was $74^{\circ} 24' 59''$ (in the old terms). Taking into consideration the distance of about 100 yards that separated the two stations and the fact that Captain Basevi's was to the west of mine, the longitude of the old pendulum station, as deduced from that of mine, must have been $74^{\circ} 24' 56''$ approximately. I am unable to explain the difference of $44''$ between Captain Basevi's value and that now deduced. It would appear that his value is not in terms of the datum of the G. T. Survey, viz., Warren's value for the Longitude of Madras, $80^{\circ} 17' 21''$. It is not, however, to be supposed that this discrepancy indicates a doubt as to the identification of Basevi's station. It was ascertained with complete certainty that his station was situated somewhere within a certain acre of ground.

The floor of the room was not good and isolated platforms were built both for the pendulums and for the clock.

The flexure correction was determined five times:—

| | 9th January | 13th January |
|--------------------|-----------------------|-----------------------|
| | 40.3×10^{-7} | 36.1×10^{-7} |
| | 42.3 | 37.6 |
| | 39.1 | ... |
| Adopted Correction | $- 39 \times 10^{-7}$ | |

Ferozepore.

| | ... | ... | ° | ' | " |
|-----------------------------|-----|-----|-----------|----|----|
| Latitude | ... | ... | 30 | 55 | 48 |
| Longitude | ... | ... | 74 | 37 | 4 |
| Height above mean sea level | ... | ... | 647 feet. | | |

The pendulum station was situated in the eastern room of the P. W. D. Rest-house, the latter stands about 570 yards east of the junction of the main road to Lahore with the Ferozepore Mall.

The height was determined by a line of levels run from a bench-mark of the G. T. Survey on the 1st mile-stone on the Lahore road.

The floor of the room was good and isolated platforms were not provided.

The flexure correction was determined six times:—

| 17th January | 19th January | 21st January |
|-----------------------|-----------------------|-----------------------|
| 51.2×10^{-7} | 47.1×10^{-7} | 48.7×10^{-7} |
| 51.8 | 48.9 | 48.4 |

For the first two sets of observations the value -50×10^{-7} was adopted and for the last set the value -48×10^{-7} .

Pathankot.

| | | | | | |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 32 | 16 | 33 |
| Longitude | ... | ... | 75 | 39 | 3 |
| Height above mean sea level | ... | | | | 1088 feet |

The pendulum station was situated in the room at the east side of the District Rest-house. This room is about 710 feet north, and 565 feet east of the centre of the platform of the railway station.

A line of levels was run from the railway to the pendulum room showing that the latter is 4.6 feet above rail-level. The height of the rails given by the railway authorities was 1083.7 feet.

The flexure correction was determined four times:—

| | |
|-----------------------|-----------------------|
| 31st January | 5th February |
| 39.8×10^{-7} | 38.5×10^{-7} |
| 40.9 | 39.8 |

Adopted Correction $- 40 \times 10^{-7}$

Montgomery.

| | | | | | |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 30 | 39 | 47 |
| Longitude | ... | ... | 73 | 6 | 18 |
| Height above mean sea level | ... | | | | 557 feet |

The pendulum station was in the Municipal Building, it was about 530 feet south and 2900 feet east of the monument to L. O. Fitzhardinge Berkeley which stands immediately in front of the cutcherry.

The height of the floor of the room was determined by levelling from the railway station.

The flexure correction was determined seven times:—

| | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 11th February | 14th February | 16th February | 20th February |
| 41.8×10^{-7} | 40.0×10^{-7} | 40.9×10^{-7} | 39.6×10^{-7} |
| 41.8 | 41.4 | ... | 40.3 |

Adopted Correction $- 41 \times 10^{-7}$

Dera Ghazi Khan.

| | | | | | |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 30 | 3 | 49 |
| Longitude | ... | ... | 70 | 45 | 38 |
| Height above mean sea level | ... | | | | 397 feet |

The pendulum station was situated in a house on the eastern side of the road which runs nearly north and south and passes between the Church and the Cutcherry. The pillar was about 1400 feet south and 430 feet west of the centre of the Church.

There had been an imbedded bench-mark of the principal levelling close to the gate of the Treasury, but it could not be found; so it was assumed that it had been 1 foot below ground level, and a line of levels was run from its probable position to the pendulum room.

The flexure correction was determined four times, and showed that a large change in the rigidity of the pillar took place while the observations were in progress, this was due to the cement being still wet when the observations began, and becoming harder gradually.

The results of the observations were:—

| 27th February | 2nd March |
|------------------------------------|------------------------------------|
| $\overset{s}{66.4} \times 10^{-7}$ | $\overset{s}{55.6} \times 10^{-7}$ |
| 65.0 | 56.8 |

The adopted corrections were:—

| | | | |
|----------|----|-------|--|
| February | 27 | Night | $\overset{s}{-59} \times 10^{-7}$ |
| „ | 28 | Day | 58×10^{-7} |
| „ | 28 | Night | $\left. \begin{array}{l} \\ \\ \\ \end{array} \right\} -57 \times 10^{-7}$ |
| March | 1 | Day | |
| „ | 1 | Night | |
| „ | 2 | Day | |

These values were obtained by drawing a curve of the same form as that found at Jalpauri in 1905, where the circumstances were similar.

Multan.

| | ° | ' | " |
|-----------------------------|----------|----|----|
| Latitude | ... 30 | 11 | 11 |
| Longitude | ... 71 | 25 | 51 |
| Height above mean sea level | 404 feet | | |

The pendulum station was in a room at the northern corner of a house which stands in the S. E. angle formed by Lake Street and Prince's Road.

The height was determined by levelling from the bench-mark in the compound of the Canal office.

The flexure correction was determined five times:—

| 7th March | 10th March | 11th March |
|------------------------------------|------------------------------------|------------------------------------|
| $\overset{s}{45.1} \times 10^{-7}$ | $\overset{s}{45.3} \times 10^{-7}$ | $\overset{s}{44.5} \times 10^{-7}$ |
| 41.3 | ... | 45.5 |

Adopted Correction

$$\overset{s}{-44} \times 10^{-7}$$

This station was very near the road and I do not think that the ground was wholly free from tremors caused by passing traffic. I did not succeed in definitely detecting their effects but I think that the less good agreement between the results of the several sets of observations may probably be ascribed to them.

Jacobabad.

| | | | | | |
|-----------------------------|-----|-----|----|-----|------|
| Latitude | ... | ... | 28 | 16 | 34 |
| Longitude | ... | ... | 68 | 27 | 5 |
| Height above mean sea level | | | | 183 | feet |

The pendulum station was situated in the large western room of the Military Works Rest-house. The pillar was about 5800 feet east and 106 feet north of the centre of the railway station. The height was determined by two separate lines of levels, the one to the nearest canal bench-mark and the other to the rails opposite the station platform.

The results differed by 1 foot only.

The flexure correction was determined five times:—

| 15th March | 18th March |
|-----------------------|-----------------------|
| 54.7×10^{-7} | 52.1×10^{-7} |
| 52.5 | 51.0 |
| 53.2 | ... |

Adopted Correction -53×10^{-7}

Sibi.

| | | | | | |
|-----------------------------|-----|-----|----|-----|------|
| Latitude | ... | ... | 29 | 32 | 46 |
| Longitude | ... | ... | 67 | 52 | 31 |
| Height above mean sea level | ... | | | 434 | feet |

The pendulum station was in the centre room of the Dāk Bungalow.

The pillar was about 390 feet south and 980 feet east of the centre of the platform of the railway station.

The height was determined by levelling from the railway lines opposite the station.

The flexure correction was determined six times:—

| 21st March | 26th March | 27th March |
|-----------------------|-----------------------|-----------------------|
| 49.4×10^{-7} | 45.6×10^{-7} | 46.9×10^{-7} |
| 49.0 | 44.5 | 46.4 |

Adopted Correction -48×10^{-7}

Bad weather was met with at this station and stars were obtained on the nights of the 21st, 23rd and 26th only. Therefore, although 5 sets of observations were made, only 2 independent results can be deduced from them.

Mach.

| | | | | | |
|-----------------------------|-----|-----|----|------|------|
| Latitude | ... | ... | 29 | 52 | 25 |
| Longitude | ... | ... | 67 | 18 | 20 |
| Height above mean sea level | ... | | | 3522 | feet |

The pendulum station was situated in the centre room of building No. 36, which stands between the Military Works Inspection House and the Rest-house or Dāk Bungalow, and about

50 yards from the former. The approximate distance and azimuth of the centre of the iron railway bridge on the opposite side of the Bolan River were 2300 feet and 276° .

The height was determined by levelling from the Sibi abutment of the above-mentioned bridge. The height of that point as determined by the railway engineers is 3430.7 feet above mean sea level and the floor of the pendulum room was found to be 91.3 feet above it.

The flexure correction was determined four times:—

| 29th March | 31st March |
|-----------------------|-----------------------|
| 40.5×10^{-7} | 38.0×10^{-7} |
| 39.2 | 36.6 |
| Adopted Correction | $- 39 \times 10^{-7}$ |

Quetta.

| | ° | ' | " |
|-----------------------------|-----------|----|----|
| Latitude | 30 | 12 | 15 |
| Longitude | 67 | 0 | 41 |
| Height above mean sea level | 5520 feet | | |

The pendulum station was situated in the small bungalow in the compound of the C.R.E.'s house, which used formerly to be the Superintending Engineer's office. The C.R.E.'s house stands in the eastern angle formed by the intersection of Phayre Road with Lytton Road. The pendulum pillar was about 126 yards from Phayre Road and 31 yards from Lytton Road. A plane table traverse was made connecting the pendulum station with the Telegraph Office S. at which a latitude and an azimuth had been observed in 1904, and the co-ordinates of which are given in Vol. XV. *Op. G. T. S.* Appendix p. (12).

The height was determined by levelling from the railway station. Rail-level at the station as determined by the railway engineers, is 5501.6 feet.

The flexure correction was determined five times:—

| 3rd April | 6th April |
|-----------------------|-----------------------|
| 42.9×10^{-7} | 41.6×10^{-7} |
| 46.3 | 40.5 |
| 42.9 | ... |
| Adopted Correction | $- 43 \times 10^{-7}$ |

Dehra Dun.

On returning to Dehra Dún the closing observations were made in the pendulum room.

The flexure observation was made four times and yielded the following values:—

| 20th April | 26th April |
|-----------------------|-----------------------|
| 40.4×10^{-7} | 36.7×10^{-7} |
| 40.7 | 37.5 |
| Adopted Correction | $- 39 \times 10^{-7}$ |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|----------------|---------|---------------------------|-----------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | | |
| Dehra Dun—(Pendulum room). | | | | | | | | | | | | | | | | | |
| 12-13 November, 1905. | | | | | | | | | | | | | | | | | |
| 137 | 1 17 | 34°051 | + | 5°85 | 13 | 21°04 | -0°08 | 0°853 | 0°5074513 | -343 | -5 | -1031 | - | 507 | -43 | 0°5072584 | |
| 139 | 2 14 | 34°491 | | 5°85 | 14 | 21°15 | 0°08 | 0°855 | 0°5073549 | 343 | 5 | 1036 | - | 518 | 43 | 0°5071604 | |
| 138 | 3 23 | 33°007 | | 5°85 | 14 | 20°96 | 0°08 | 0°855 | 0°5070907 | 343 | 5 | 1027 | - | 489 | 43 | 0°5075000 | |
| 140 | 4 20 | 34°843 | | 5°85 | 13 | 20°91 | 0°08 | 0°856 | 0°5072795 | 343 | 5 | 1024 | - | 519 | 43 | 0°5070861 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072512 | |
| 137 | 13 25 | 34°064 | + | 5°85 | 13 | 20°71 | +0°12 | 0°857 | 0°5074485 | -343 | -5 | -1015 | - | 509 | -43 | 0°5072570 | |
| 139 | 14 23 | 34°500 | | 5°85 | 15 | 20°81 | 0°12 | 0°857 | 0°5073528 | 343 | 6 | 1020 | - | 519 | 43 | 0°5071597 | |
| 138 | 15 19 | 33°015 | | 5°85 | 16 | 20°97 | 0°12 | 0°856 | 0°5076888 | 343 | 7 | 1028 | - | 490 | 43 | 0°5074977 | |
| 140 | 16 18 | 34°848 | | 5°85 | 10 | 21°00 | 0°12 | 0°855 | 0°5072786 | 343 | 3 | 1029 | - | 518 | 43 | 0°5070850 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072499 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | ... | 0°5072505 |
| 13-14 November, 1905. | | | | | | | | | | | | | | | | | |
| 140 | 1 23 | 34°848 | + | 5°95 | 17 | 20°92 | -0°01 | 0°856 | 0°5072786 | -349 | -8 | -1025 | - | 519 | -43 | 0°5070842 | |
| 138 | 2 22 | 33°011 | | 5°95 | 15 | 21°04 | 0°01 | 0°856 | 0°5076897 | 349 | 6 | 1031 | - | 490 | 43 | 0°5074978 | |
| 139 | 3 19 | 34°501 | | 5°95 | 14 | 20°93 | 0°01 | 0°857 | 0°5073527 | 349 | 5 | 1026 | - | 519 | 43 | 0°5071585 | |
| 137 | 4 16 | 34°055 | | 5°95 | 12 | 20°98 | 0°01 | 0°856 | 0°5074505 | 349 | 4 | 1028 | - | 508 | 43 | 0°5072573 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072495 | |
| 140 | 13 38 | 34°848 | + | 5°95 | 14 | 20°62 | +0°09 | 0°859 | 0°5072785 | -349 | -5 | -1010 | - | 521 | -43 | 0°5070857 | |
| 138 | 14 37 | 33°014 | | 5°95 | 14 | 20°78 | 0°09 | 0°857 | 0°5076889 | 349 | 5 | 1018 | - | 490 | 43 | 0°5074984 | |
| 139 | 15 40 | 34°498 | | 5°95 | 14 | 20°83 | 0°09 | 0°857 | 0°5073532 | 349 | 5 | 1021 | - | 519 | 43 | 0°5071595 | |
| 137 | 16 38 | 34°052 | | 5°95 | 12 | 20°93 | 0°09 | 0°856 | 0°5074511 | 349 | 4 | 1026 | - | 508 | 43 | 0°5072581 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072504 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | ... | 0°5072499 |
| 14-15 November, 1905. | | | | | | | | | | | | | | | | | |
| 137 | 1 27 | 34°045 | + | 6°16 | 13 | 20°76 | +0°03 | 0°856 | 0°5074527 | -362 | -5 | -1017 | - | 508 | -43 | 0°5072592 | |
| 139 | 2 24 | 34°488 | | 6°16 | 14 | 20°77 | 0°03 | 0°856 | 0°5073556 | 362 | 5 | 1018 | - | 519 | 43 | 0°5071609 | |
| 138 | 3 19 | 32°997 | | 6°16 | 15 | 20°81 | 0°03 | 0°856 | 0°5076929 | 362 | 6 | 1020 | - | 490 | 43 | 0°5075008 | |
| 140 | 4 14 | 34°836 | | 6°16 | 13 | 20°82 | 0°03 | 0°856 | 0°5072811 | 362 | 5 | 1020 | - | 519 | 43 | 0°5070862 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072518 | |
| 137 | 13 48 | 34°045 | + | 6°16 | 13 | 20°58 | +0°08 | 0°858 | 0°5074527 | -362 | -5 | -1008 | - | 510 | -43 | 0°5072599 | |
| 139 | 14 49 | 34°495 | | 6°16 | 14 | 20°69 | 0°08 | 0°857 | 0°5073540 | 362 | 5 | 1014 | - | 519 | 43 | 0°5071597 | |
| 138 | 15 46 | 33°004 | | 6°16 | 16 | 20°78 | 0°08 | 0°857 | 0°5076915 | 362 | 7 | 1018 | - | 490 | 43 | 0°5074995 | |
| 140 | 16 43 | 34°841 | | 6°16 | 14 | 20°80 | 0°08 | 0°856 | 0°5072800 | 362 | 5 | 1019 | - | 519 | 43 | 0°5070852 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5072511 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | ... | 0°5072514 |
| General Mean | | | | | | | | | | | | | | | | ... | 0°5072506 |
| Simla. | | | | | | | | | | | | | | | | | |
| 15-16 December, 1905. | | | | | | | | | | | | | | | | | |
| 137 | 3 25 | 34°277 | - | 2°36 | 15 | 10°45 | +0°03 | 0°749 | 0°5074012 | +139 | -6 | -512 | - | 445 | -35 | 0°5073153 | |
| 139 | 4 22 | 34°726 | | 2°36 | 16 | 10°56 | 0°03 | 0°748 | 0°5073043 | 139 | 7 | 517 | - | 453 | 35 | 0°5072170 | |
| 138 | 5 16 | 33°215 | | 2°36 | 17 | 10°58 | 0°03 | 0°747 | 0°5076417 | 139 | 8 | 518 | - | 427 | 35 | 0°5075568 | |
| 140 | 6 11 | 35°078 | | 2°36 | 15 | 10°56 | 0°03 | 0°747 | 0°5072300 | 139 | 6 | 517 | - | 453 | 35 | 0°5071428 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5073080 | |
| 137 | 15 39 | 34°272 | - | 2°36 | 15 | 10°67 | +0°07 | 0°748 | 0°5074025 | +139 | -6 | -523 | - | 444 | -35 | 0°5073156 | |
| 139 | 16 32 | 34°718 | | 2°36 | 16 | 10°67 | 0°07 | 0°748 | 0°5073060 | 139 | 7 | 523 | - | 453 | 35 | 0°5072181 | |
| 138 | 17 26 | 33°211 | | 2°36 | 17 | 10°76 | 0°07 | 0°748 | 0°5076427 | 139 | 8 | 527 | - | 428 | 35 | 0°5075568 | |
| 140 | 18 26 | 35°074 | | 2°36 | 14 | 10°84 | 0°07 | 0°748 | 0°5072308 | 139 | 5 | 531 | - | 453 | 35 | 0°5071423 | |
| | | | | | | | | | | | | | Not applied | Mean | ... | 0°5073082 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | | ... | 0°5073081 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|------|----------------|---------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 31 December, 1905—1 January, 1906. | | | | | | | | | | | | | | | | |
| 140 | 4 23 | 35.170 | + | 6.33 | 17 | 17.04 | +0.04 | 0.916 | 0.5072108 | -372 | -8 | -835 | Not applied | -555 | -43 | 0.5070295 |
| 138 | 5 22 | 33.207 | | 6.33 | 18 | 16.92 | 0.04 | 0.916 | 0.5076226 | 372 | 9 | 829 | | 524 | 43 | 0.5074449 |
| 139 | 6 18 | 34.816 | | 6.33 | 17 | 16.94 | 0.04 | 0.916 | 0.5072852 | 372 | 8 | 830 | | 555 | 43 | 0.5071044 |
| 137 | 7 17 | 34.362 | | 6.33 | 15 | 17.17 | 0.04 | 0.915 | 0.5073830 | 372 | 6 | 841 | | 544 | 43 | 0.5072024 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071953 |
| 140 | 16 26 | 35.167 | + | 6.33 | 17 | 16.56 | -0.02 | 0.918 | 0.5072115 | -372 | -8 | -811 | Not applied | -556 | -43 | 0.5070325 |
| 138 | 17 25 | 33.203 | | 6.33 | 18 | 16.63 | 0.02 | 0.918 | 0.5076237 | 372 | 9 | 815 | | 525 | 43 | 0.5074473 |
| 139 | 18 21 | 34.811 | | 6.33 | 18 | 16.53 | 0.02 | 0.917 | 0.5072863 | 372 | 9 | 810 | | 556 | 43 | 0.5071073 |
| 137 | 19 22 | 34.363 | | 6.33 | 16 | 16.59 | 0.02 | 0.917 | 0.5073827 | 372 | 7 | 813 | | 545 | 43 | 0.5072047 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071979 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | ... | 0.5071966 |
| 2-3 January, 1906. | | | | | | | | | | | | | | | | |
| 139 | 4 30 | 34.787 | + | 7.57 | 17 | 16.65 | +0.04 | 0.916 | 0.5072915 | -444 | -8 | -816 | Not applied | -555 | -43 | 0.5071049 |
| 137 | 5 29 | 34.335 | | 7.57 | 14 | 16.78 | 0.04 | 0.914 | 0.5073888 | 444 | 5 | 822 | | 543 | 43 | 0.5072031 |
| 140 | 6 25 | 35.141 | | 7.57 | 15 | 16.76 | 0.04 | 0.916 | 0.5072167 | 444 | 6 | 821 | | 555 | 43 | 0.5070298 |
| 138 | 7 23 | 33.271 | | 7.57 | 16 | 16.83 | 0.04 | 0.914 | 0.5076288 | 444 | 7 | 825 | | 523 | 43 | 0.5074446 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071956 |
| 139 | 16 38 | 34.784 | + | 7.57 | 17 | 16.41 | +0.07 | 0.919 | 0.5072921 | -444 | -8 | -804 | Not applied | -557 | -43 | 0.5071065 |
| 137 | 17 38 | 34.335 | | 7.57 | 13 | 16.44 | 0.07 | 0.919 | 0.5073888 | 444 | 5 | 806 | | 546 | 43 | 0.5072044 |
| 140 | 18 38 | 35.146 | | 7.57 | 15 | 16.52 | 0.07 | 0.918 | 0.5072158 | 444 | 6 | 809 | | 556 | 43 | 0.5070300 |
| 138 | 19 37 | 33.271 | | 7.57 | 17 | 16.59 | 0.07 | 0.918 | 0.5076287 | 444 | 8 | 813 | | 525 | 43 | 0.5074454 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071966 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | ... | 0.5071961 |
| 3-4 January, 1906. | | | | | | | | | | | | | | | | |
| 138 | 4 25 | 33.258 | + | 7.94 | 18 | 16.85 | +0.06 | 0.918 | 0.5076316 | -466 | -9 | -826 | Not applied | -525 | -43 | 0.5074447 |
| 140 | 5 20 | 35.123 | | 7.94 | 15 | 16.91 | 0.06 | 0.917 | 0.5072206 | 466 | 6 | 829 | | 556 | 43 | 0.5070306 |
| 137 | 6 13 | 34.319 | | 7.94 | 15 | 16.95 | 0.06 | 0.917 | 0.5073922 | 466 | 6 | 831 | | 545 | 43 | 0.5072031 |
| 139 | 7 5 | 34.765 | | 7.94 | 16 | 17.02 | 0.06 | 0.917 | 0.5072960 | 466 | 7 | 834 | | 556 | 43 | 0.5071054 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071959 |
| 138 | 16 45 | 33.270 | + | 7.94 | 18 | 15.92 | +0.04 | 0.923 | 0.5076288 | -466 | -9 | -780 | Not applied | -528 | -43 | 0.5074462 |
| 140 | 17 37 | 35.138 | | 7.94 | 15 | 16.03 | 0.04 | 0.922 | 0.5072175 | 466 | 6 | 785 | | 559 | 43 | 0.5070316 |
| 137 | 18 30 | 34.339 | | 7.94 | 14 | 16.05 | 0.04 | 0.922 | 0.5073878 | 466 | 5 | 786 | | 548 | 43 | 0.5072030 |
| 139 | 19 23 | 34.784 | | 7.94 | 15 | 16.05 | 0.04 | 0.920 | 0.5072922 | 466 | 6 | 786 | | 558 | 43 | 0.5071063 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071968 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | ... | 0.5071964 |
| General Mean | | | | | | | | | | | | | | | ... | 0.5071965 |
| Mian Mir. | | | | | | | | | | | | | | | | |
| 10-11 January, 1906. | | | | | | | | | | | | | | | | |
| 137 | 5 22 | 34.617 | + | 4.19 | 16 | 14.43 | +0.16 | 0.929 | 0.5073277 | -246 | -7 | -707 | Not applied | -552 | -39 | 0.5071726 |
| 139 | 6 17 | 35.061 | | 4.19 | 16 | 14.68 | 0.16 | 0.928 | 0.5072335 | 246 | 7 | 719 | | 562 | 39 | 0.5070762 |
| 138 | 7 11 | 33.522 | | 4.19 | 17 | 14.78 | 0.16 | 0.928 | 0.5075707 | 246 | 8 | 724 | | 531 | 39 | 0.5074159 |
| 140 | 8 0 | 35.420 | | 4.19 | 16 | 14.89 | 0.16 | 0.926 | 0.5071593 | 246 | 7 | 730 | | 561 | 39 | 0.5070010 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071664 |
| 137 | 17 18 | 34.590 | + | 4.19 | 16 | 14.69 | +0.01 | 0.930 | 0.5073386 | -246 | -7 | -720 | Not applied | -552 | -39 | 0.5071772 |
| 139 | 18 10 | 35.047 | | 4.19 | 17 | 14.76 | 0.01 | 0.929 | 0.5072366 | 246 | 8 | 723 | | 563 | 39 | 0.5070787 |
| 138 | 19 4 | 33.506 | | 4.19 | 17 | 14.73 | 0.01 | 0.929 | 0.5075743 | 246 | 8 | 722 | | 531 | 39 | 0.5074197 |
| 140 | 19 58 | 35.404 | | 4.19 | 16 | 14.74 | 0.01 | 0.929 | 0.5071625 | 246 | 7 | 722 | | 563 | 39 | 0.5070048 |
| | | | | | | | | | | | | | | Mean | ... | 0.5071701 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | | ... | 0.5071683 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|----------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| 20-21 January, 1906. | | | | | | | | | | | | | | | |
| 139 | 9 16 | 34.998 | + | 4.29 | 17 | 14.70 | +0.03 | 0.925 | 0.5072468 | -252 | -8 | -720 | -561 | -48 | 0.5070879 |
| 137 | 10 15 | 34.540 | | 4.29 | 14 | 14.79 | 0.03 | 0.925 | 0.5073442 | 252 | 5 | 725 | 549 | 48 | 0.5071863 |
| 140 | 11 13 | 35.358 | | 4.29 | 16 | 14.79 | 0.03 | 0.925 | 0.5071718 | 252 | 7 | 725 | 561 | 48 | 0.5070125 |
| 138 | 12 12 | 33.464 | | 4.29 | 17 | 14.82 | 0.03 | 0.925 | 0.5075840 | 252 | 8 | 726 | 529 | 48 | 0.5074277 |
| | | | | | | | | | | | | | Not applied | | |
| | | | | | | | | | | | | | Mean | ... | 0.5071786 |
| 139 | 21 17 | 34.997 | + | 4.29 | 18 | 14.43 | +0.10 | 0.928 | 0.5072470 | -252 | -9 | -707 | -562 | -48 | 0.5070892 |
| 137 | 22 21 | 34.539 | | 4.29 | 16 | 14.50 | 0.10 | 0.928 | 0.5073445 | 252 | 7 | 711 | 551 | 48 | 0.5071876 |
| 140 | 23 18 | 35.355 | | 4.29 | 17 | 14.63 | 0.10 | 0.925 | 0.5071727 | 252 | 8 | 717 | 561 | 48 | 0.5070141 |
| 138 | 0 15 | 33.461 | | 4.29 | 19 | 14.68 | 0.10 | 0.925 | 0.5075848 | 252 | 10 | 719 | 529 | 48 | 0.5074290 |
| | | | | | | | | | | | | | Mean | ... | 0.5071799 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5071793 |
| | | | | | | | | | | | | | General Mean | ... | 0.5071791 |
| Fathankot. | | | | | | | | | | | | | | | |
| 2-3 February, 1906. | | | | | | | | | | | | | | | |
| 137 | 6 26 | 34.497 | + | 0.61 | 16 | 16.06 | +0.11 | 0.907 | 0.5073536 | -36 | -7 | -787 | -539 | -40 | 0.5072127 |
| 139 | 7 22 | 34.949 | | 0.61 | 18 | 16.29 | 0.11 | 0.906 | 0.5072570 | 36 | 9 | 798 | 549 | 40 | 0.5071138 |
| 138 | 8 20 | 33.419 | | 0.61 | 18 | 16.36 | 0.11 | 0.904 | 0.5075942 | 36 | 9 | 802 | 517 | 40 | 0.5074538 |
| 140 | 9 16 | 35.294 | | 0.61 | 17 | 16.41 | 0.11 | 0.904 | 0.5071852 | 36 | 8 | 804 | 548 | 40 | 0.5070416 |
| | | | | | | | | | | | | | Not applied | | |
| | | | | | | | | | | | | | Mean | ... | 0.5072055 |
| 137 | 18 21 | 34.488 | + | 0.61 | 17 | 16.00 | +0.08 | 0.911 | 0.5073556 | -36 | -8 | -784 | -541 | -40 | 0.5072147 |
| 139 | 19 17 | 34.950 | | 0.61 | 18 | 16.09 | 0.08 | 0.911 | 0.5072568 | 36 | 9 | 788 | 552 | 40 | 0.5071143 |
| 138 | 20 12 | 33.420 | | 0.61 | 19 | 16.18 | 0.08 | 0.911 | 0.5075940 | 36 | 10 | 793 | 521 | 40 | 0.5074540 |
| 140 | 21 10 | 35.308 | | 0.61 | 17 | 16.23 | 0.08 | 0.911 | 0.5071823 | 36 | 8 | 795 | 552 | 40 | 0.5070392 |
| | | | | | | | | | | | | | Mean | ... | 0.5072056 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072055 |
| 3-4 February, 1906. | | | | | | | | | | | | | | | |
| 140 | 6 6 | 35.311 | + | 0.43 | 18 | 15.93 | +0.01 | 0.912 | 0.5071816 | -25 | -9 | -781 | -553 | -40 | 0.5070408 |
| 138 | 7 6 | 33.421 | | 0.43 | 18 | 15.99 | 0.01 | 0.909 | 0.5075940 | 25 | 9 | 784 | 520 | 40 | 0.5074562 |
| 139 | 8 3 | 34.947 | | 0.43 | 18 | 15.98 | 0.01 | 0.911 | 0.5072576 | 25 | 9 | 783 | 552 | 40 | 0.5071167 |
| 137 | 9 0 | 34.497 | | 0.43 | 16 | 15.98 | 0.01 | 0.911 | 0.5073535 | 25 | 7 | 783 | 541 | 40 | 0.5072139 |
| | | | | | | | | | | | | | Not applied | | |
| | | | | | | | | | | | | | Mean | ... | 0.5072069 |
| 140 | 18 8 | 35.312 | + | 0.43 | 18 | 15.54 | +0.13 | 0.914 | 0.5071813 | -25 | -9 | -761 | -554 | -40 | 0.5070424 |
| 138 | 19 4 | 33.425 | | 0.43 | 19 | 15.68 | 0.13 | 0.913 | 0.5075931 | 25 | 10 | 768 | 522 | 40 | 0.5074566 |
| 139 | 19 59 | 34.952 | | 0.43 | 18 | 15.81 | 0.13 | 0.913 | 0.5072563 | 25 | 9 | 775 | 553 | 40 | 0.5071161 |
| 137 | 20 55 | 34.499 | | 0.43 | 16 | 15.89 | 0.13 | 0.912 | 0.5073531 | 25 | 7 | 779 | 542 | 40 | 0.5072138 |
| | | | | | | | | | | | | | Mean | ... | 0.5072072 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072071 |
| 4-5 February, 1906. | | | | | | | | | | | | | | | |
| 139 | 6 22 | 34.952 | + | 0.72 | 18 | 15.85 | +0.05 | 0.912 | 0.5072565 | -42 | -9 | -777 | -553 | -40 | 0.5071144 |
| 137 | 7 20 | 34.489 | | 0.72 | 16 | 15.97 | 0.05 | 0.911 | 0.5073555 | 42 | 7 | 783 | 541 | 40 | 0.5072142 |
| 140 | 8 21 | 35.302 | | 0.72 | 17 | 15.94 | 0.05 | 0.912 | 0.5071835 | 42 | 8 | 781 | 553 | 40 | 0.5070411 |
| 138 | 9 20 | 33.420 | | 0.72 | 17 | 16.06 | 0.05 | 0.911 | 0.5075942 | 42 | 8 | 787 | 521 | 40 | 0.5074544 |
| | | | | | | | | | | | | | Not applied | | |
| | | | | | | | | | | | | | Mean | ... | 0.5072060 |
| 139 | 18 30 | 34.945 | + | 0.72 | 19 | 15.87 | +0.11 | 0.910 | 0.5072580 | -42 | -10 | -778 | -551 | -40 | 0.5071159 |
| 137 | 19 26 | 34.491 | | 0.72 | 16 | 15.99 | 0.11 | 0.909 | 0.5073548 | 42 | 7 | 784 | 540 | 40 | 0.5072135 |
| 140 | 20 24 | 35.301 | | 0.72 | 21 | 16.10 | 0.11 | 0.909 | 0.5071838 | 42 | 12 | 789 | 551 | 40 | 0.5070404 |
| 138 | 21 23 | 33.425 | | 0.72 | 16 | 16.19 | 0.11 | 0.908 | 0.5075929 | 42 | 7 | 793 | 519 | 40 | 0.5074528 |
| | | | | | | | | | | | | | Mean | ... | 0.5072056 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072058 |
| | | | | | | | | | | | | | General Mean | ... | 0.5072061 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------------|----------------|---------|---------------------------|--|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 28 February—1 March, 1906. | | | | | | | | | | | | | | | | |
| 140 | 7 59 | 35.392 | — 4.11 | 19 | 15.19 | + 0.04 | 0.939 | 0.5071649 | + 241 | - 10 | - 744 | Not applied | - 569 | - 57 | 0.5070510 | |
| 138 | 9 5 | 33.501 | 4.11 | 18 | 15.21 | 0.04 | 0.939 | 0.5075755 | 241 | 9 | 745 | | 537 | 57 | 0.5074648 | |
| 139 | 10 4 | 35.034 | 4.11 | 18 | 15.25 | 0.04 | 0.938 | 0.5072392 | 241 | 9 | 747 | | 568 | 57 | 0.5071252 | |
| 137 | 11 3 | 34.567 | 4.11 | 19 | 15.31 | 0.04 | 0.938 | 0.5073385 | 241 | 10 | 750 | | 557 | 57 | 0.5072252 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072166 | |
| 140 | 20 2 | 35.388 | — 4.11 | 19 | 15.13 | 0.00 | 0.939 | 0.5071656 | + 241 | - 10 | - 741 | Not applied | - 569 | - 57 | 0.5070520 | |
| 138 | 21 2 | 33.498 | 4.11 | 20 | 15.11 | 0.00 | 0.939 | 0.5075761 | 241 | 11 | 740 | | 537 | 57 | 0.5074657 | |
| 139 | 22 1 | 35.034 | 4.11 | 18 | 15.11 | 0.00 | 0.939 | 0.5072392 | 241 | 9 | 740 | | 569 | 57 | 0.5071258 | |
| 137 | 23 1 | 34.569 | 4.11 | 18 | 15.13 | 0.00 | 0.938 | 0.5073381 | 241 | 9 | 741 | | 557 | 57 | 0.5072258 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072173 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072169 | |
| 1-2 March, 1906. | | | | | | | | | | | | | | | | |
| 139 | 7 55 | 35.015 | — 3.93 | 19 | 15.56 | - 0.02 | 0.934 | 0.5072430 | + 231 | - 10 | - 762 | Not applied | - 566 | - 57 | 0.5071266 | |
| 137 | 8 54 | 34.550 | 3.93 | 18 | 15.57 | 0.02 | 0.934 | 0.5073422 | 231 | 9 | 763 | | 555 | 57 | 0.5072269 | |
| 140 | 9 54 | 35.377 | 3.93 | 18 | 15.53 | 0.02 | 0.935 | 0.5071680 | 231 | 9 | 761 | | 567 | 57 | 0.5070517 | |
| 138 | 10 52 | 33.480 | 3.93 | 18 | 15.53 | 0.02 | 0.935 | 0.5075803 | 231 | 9 | 761 | | 535 | 57 | 0.5074672 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072181 | |
| 139 | 20 7 | 35.011 | — 3.93 | 19 | 15.66 | - 0.01 | 0.937 | 0.5072441 | + 231 | - 10 | - 767 | Not applied | - 568 | - 57 | 0.5071270 | |
| 137 | 21 8 | 34.559 | 3.93 | 18 | 15.62 | 0.01 | 0.937 | 0.5073402 | 231 | 9 | 765 | | 557 | 57 | 0.5072245 | |
| 140 | 22 7 | 35.572 | 3.93 | 18 | 15.62 | 0.01 | 0.937 | 0.5071690 | 231 | 9 | 765 | | 568 | 57 | 0.5070522 | |
| 138 | 23 13 | 33.487 | 3.93 | 18 | 15.64 | 0.01 | 0.937 | 0.5075787 | 231 | 9 | 766 | | 536 | 57 | 0.5074650 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072172 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072176 | |
| General Mean | | | | | | | | | | | | | | ... | 0.5072177 | |
| Multan. | | | | | | | | | | | | | | | | |
| 7-8 March, 1906. | | | | | | | | | | | | | | | | |
| 137 | 8 52 | 34.547 | — 1.68 | 18 | 16.91 | + 0.03 | 0.928 | 0.5073428 | + 99 | - 9 | - 829 | Not applied | - 551 | - 44 | 0.5072094 | |
| 139 | 9 51 | 35.002 | 1.68 | 19 | 17.00 | 0.03 | 0.928 | 0.5072459 | 99 | 10 | 833 | | 562 | 44 | 0.5071109 | |
| 138 | 10 48 | 33.462 | 1.68 | 19 | 17.03 | 0.03 | 0.927 | 0.5075845 | 99 | 10 | 834 | | 530 | 44 | 0.5074526 | |
| 140 | 11 46 | 35.349 | 1.68 | 19 | 16.98 | 0.03 | 0.927 | 0.5071737 | 99 | 10 | 832 | | 562 | 44 | 0.5070388 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072029 | |
| 137 | 20 43 | 34.536 | — 1.68 | 20 | 16.64 | + 0.12 | 0.929 | 0.5073452 | + 99 | - 11 | - 815 | Not applied | - 552 | - 44 | 0.5072129 | |
| 139 | 21 42 | 34.999 | 1.68 | 19 | 16.81 | 0.12 | 0.927 | 0.5072465 | 99 | 10 | 824 | | 562 | 44 | 0.5071124 | |
| 138 | 22 41 | 33.463 | 1.68 | 19 | 16.92 | 0.12 | 0.927 | 0.5075843 | 99 | 10 | 829 | | 530 | 44 | 0.5074529 | |
| 140 | 23 42 | 35.350 | 1.68 | 18 | 17.00 | 0.12 | 0.926 | 0.5071735 | 99 | 9 | 853 | | 561 | 44 | 0.5070387 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072042 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072036 | |
| 8-9 March, 1906. | | | | | | | | | | | | | | | | |
| 140 | 8 40 | 35.330 | — 1.27 | 20 | 17.32 | + 0.06 | 0.922 | 0.5071777 | + 75 | - 11 | - 849 | Not applied | - 559 | - 44 | 0.5070389 | |
| 138 | 9 39 | 33.438 | 1.27 | 19 | 17.38 | 0.06 | 0.921 | 0.5075901 | 75 | 10 | 852 | | 527 | 44 | 0.5074543 | |
| 139 | 10 36 | 34.969 | 1.27 | 18 | 17.43 | 0.06 | 0.920 | 0.5072528 | 75 | 9 | 854 | | 558 | 44 | 0.5071138 | |
| 137 | 11 36 | 34.507 | 1.27 | 19 | 17.50 | 0.06 | 0.920 | 0.5073513 | 75 | 10 | 858 | | 546 | 44 | 0.5072130 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072050 | |
| 140 | 20 53 | 35.321 | — 1.27 | 20 | 17.43 | + 0.08 | 0.922 | 0.5071797 | + 75 | - 11 | - 854 | Not applied | - 559 | - 44 | 0.5070404 | |
| 138 | 21 53 | 33.429 | 1.27 | 19 | 17.51 | 0.08 | 0.922 | 0.5075921 | 75 | 10 | 858 | | 527 | 44 | 0.5074557 | |
| 139 | 22 55 | 34.964 | 1.27 | 18 | 17.59 | 0.08 | 0.922 | 0.5072538 | 75 | 9 | 862 | | 559 | 44 | 0.5071139 | |
| 137 | 23 55 | 34.502 | 1.27 | 19 | 17.65 | 0.08 | 0.921 | 0.5073525 | 75 | 10 | 865 | | 547 | 44 | 0.5072134 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072059 | |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | | ... | 0.5072054 | |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| 9-10 March, 1906. | | | | | | | | | | | | | | | |
| 139 | 8 53 | 34' 951 | - 0.93 | 20 | 18.15 | - 0.02 | 0.921 | 0.5072566 | + 55 | - 11 | - 889 | - 558 | - 44 | 0.5071119 | |
| 137 | 9 50 | 34' 484 | 0.93 | 20 | 18.08 | 0.02 | 0.921 | 0.5073562 | 55 | 11 | 886 | 547 | 44 | 0.5072129 | |
| 140 | 10 47 | 35' 304 | 0.93 | 19 | 18.03 | 0.02 | 0.921 | 0.5071830 | 55 | 10 | 883 | 558 | 44 | 0.5070390 | |
| 138 | 11 47 | 33' 425 | 0.93 | 18 | 18.12 | 0.02 | 0.921 | 0.5075930 | 55 | 9 | 888 | 527 | 44 | 0.5074517 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072039 |
| 139 | 21 5 | 34' 954 | - 0.93 | 20 | 17.72 | + 0.09 | 0.923 | 0.5072561 | + 55 | - 11 | - 868 | - 559 | - 44 | 0.5071134 | |
| 137 | 22 10 | 34' 490 | 0.93 | 18 | 17.83 | 0.09 | 0.922 | 0.5073549 | 55 | 9 | 874 | 548 | 44 | 0.5072129 | |
| 140 | 23 6 | 35' 305 | 0.93 | 19 | 17.91 | 0.09 | 0.921 | 0.5071830 | 55 | 10 | 878 | 558 | 44 | 0.5070395 | |
| 138 | 0 7 | 33' 417 | 0.93 | 19 | 17.98 | 0.09 | 0.920 | 0.5075949 | 55 | 10 | 881 | 526 | 44 | 0.5074543 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072050 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072045 |
| | | | | | | | | | | | | | General Mean | ... | 0.5072045 |
| Jacobabad. | | | | | | | | | | | | | | | |
| 15-16 March, 1906. | | | | | | | | | | | | | | | |
| 137 | 9 4 | 34' 355 | - 1.35 | 18 | 21.14 | - 0.04 | 0.919 | 0.5073845 | + 79 | - 9 | - 1036 | - 546 | - 53 | 0.5072280 | |
| 139 | 10 2 | 34' 819 | 1.35 | 19 | 21.16 | 0.04 | 0.918 | 0.5072847 | 79 | 10 | 1037 | 556 | 53 | 0.5071270 | |
| 138 | 11 0 | 33' 297 | 1.35 | 19 | 21.15 | 0.04 | 0.918 | 0.5076227 | 79 | 10 | 1036 | 525 | 53 | 0.5074682 | |
| 140 | 11 58 | 35' 172 | 1.35 | 18 | 20.99 | 0.04 | 0.919 | 0.5072105 | 79 | 9 | 1029 | 557 | 53 | 0.5070536 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072192 |
| 137 | 21 3 | 34' 360 | - 1.35 | 19 | 21.06 | + 0.06 | 0.921 | 0.5073833 | + 79 | - 10 | - 1032 | - 547 | - 53 | 0.5072270 | |
| 139 | 22 5 | 34' 814 | 1.35 | 20 | 21.13 | 0.06 | 0.919 | 0.5072858 | 79 | 11 | 1035 | 557 | 53 | 0.5071281 | |
| 138 | 23 5 | 33' 297 | 1.35 | 19 | 21.19 | 0.06 | 0.919 | 0.5076228 | 79 | 10 | 1038 | 526 | 53 | 0.5074680 | |
| 140 | 0 7 | 35' 168 | 1.35 | 18 | 21.24 | 0.06 | 0.918 | 0.5072112 | 79 | 9 | 1041 | 556 | 53 | 0.5070532 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072191 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072191 |
| 16-17 March, 1906. | | | | | | | | | | | | | | | |
| 140 | 9 16 | 35' 164 | - 0.99 | 18 | 21.36 | + 0.04 | 0.916 | 0.5072121 | + 58 | - 9 | - 1047 | - 555 | - 53 | 0.5070515 | |
| 138 | 10 13 | 33' 291 | 0.99 | 19 | 21.44 | 0.04 | 0.916 | 0.5076241 | 58 | 10 | 1051 | 524 | 53 | 0.5074661 | |
| 139 | 11 14 | 34' 810 | 0.99 | 19 | 21.46 | 0.04 | 0.916 | 0.5072865 | 58 | 10 | 1052 | 555 | 53 | 0.5071253 | |
| 137 | 12 12 | 34' 345 | 0.99 | 19 | 21.47 | 0.04 | 0.916 | 0.5073867 | 58 | 10 | 1052 | 544 | 53 | 0.5072266 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072174 |
| 140 | 21 24 | 35' 136 | - 0.99 | 18 | 22.16 | - 0.01 | 0.915 | 0.5072179 | + 58 | - 9 | - 1086 | - 554 | - 53 | 0.5070535 | |
| 138 | 22 23 | 33' 266 | 0.99 | 19 | 22.15 | 0.01 | 0.915 | 0.5076299 | 58 | 10 | 1085 | 523 | 53 | 0.5074686 | |
| 139 | 23 26 | 34' 778 | 0.99 | 18 | 22.14 | 0.01 | 0.915 | 0.5072932 | 58 | 9 | 1085 | 554 | 53 | 0.5071349 | |
| 137 | 0 32 | 34' 325 | 0.99 | 18 | 22.14 | 0.01 | 0.914 | 0.5073911 | 58 | 9 | 1085 | 543 | 53 | 0.5072279 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072212 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072193 |
| 17-18 March, 1906. | | | | | | | | | | | | | | | |
| 139 | 9 7 | 34' 775 | - 0.77 | 22 | 22.18 | - 0.05 | 0.912 | 0.5072940 | + 45 | - 13 | - 1087 | - 553 | - 53 | 0.5071270 | |
| 137 | 10 3 | 34' 324 | 0.77 | 17 | 22.17 | 0.05 | 0.912 | 0.5073912 | 45 | 8 | 1086 | 542 | 53 | 0.5072268 | |
| 140 | 11 3 | 35' 130 | 0.77 | 19 | 22.09 | 0.05 | 0.914 | 0.5072192 | 45 | 10 | 1082 | 554 | 53 | 0.5070538 | |
| 138 | 12 1 | 33' 266 | 0.77 | 20 | 22.07 | 0.05 | 0.914 | 0.5076298 | 45 | 11 | 1081 | 523 | 53 | 0.5074675 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072190 |
| 139 | 21 19 | 34' 785 | - 0.77 | 17 | 21.73 | + 0.09 | 0.917 | 0.5072917 | + 45 | - 8 | - 1065 | - 556 | - 53 | 0.5071280 | |
| 137 | 22 23 | 34' 330 | 0.77 | 19 | 21.82 | 0.09 | 0.917 | 0.5073899 | 45 | 10 | 1069 | 545 | 53 | 0.5072267 | |
| 140 | 23 28 | 35' 133 | 0.77 | 19 | 21.92 | 0.09 | 0.917 | 0.5072186 | 45 | 10 | 1074 | 556 | 53 | 0.5070538 | |
| 138 | 0 31 | 33' 265 | 0.77 | 18 | 22.01 | 0.09 | 0.916 | 0.5076300 | 45 | 9 | 1078 | 524 | 53 | 0.5074681 | |
| | | | | | | | | | | | | | Mean | ... | 0.5072192 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072191 |
| | | | | | | | | | | | | | General Mean | ... | 0.5072192 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-------|-------------|-------|------------------------------------|---------------------------|------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| Sibi. | | | | | | | | | | | | | | | |
| 21-22 March, 1906. | | | | | | | | | | | | | | | |
| 137 | 10 2 | 34' 296 | - | 3' 40 | 20 | 23' 18 | +0' 01 | 0' 902 | 0' 5073973 | + 200 | -11 | -1136 | - 536 | -48 | 0' 5072442 |
| 139 | 11 3 | 34' 755 | | 3' 40 | 19 | 23' 09 | 0' 01 | 0' 902 | 0' 5072981 | 200 | 10 | 1131 | 547 | 48 | 0' 5071445 |
| 138 | 12 1 | 33' 240 | | 3' 40 | 19 | 23' 15 | 0' 01 | 0' 901 | 0' 5076360 | 200 | 10 | 1134 | 515 | 48 | 0' 5074853 |
| 140 | 12 58 | 35' 105 | | 3' 40 | 20 | 23' 15 | 0' 01 | 0' 901 | 0' 5072243 | 200 | 11 | 1134 | 546 | 48 | 0' 5070704 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072361 |
| 137 | 21 53 | 34' 300 | - | 3' 40 | 19 | 22' 99 | +0' 02 | 0' 903 | 0' 5073963 | + 200 | -10 | -1127 | - 536 | -48 | 0' 5072442 |
| 139 | 22 52 | 34' 755 | | 3' 40 | 19 | 23' 01 | 0' 02 | 0' 903 | 0' 5072982 | 200 | 10 | 1127 | 547 | 48 | 0' 5071450 |
| 138 | 23 54 | 33' 244 | | 3' 40 | 18 | 23' 02 | 0' 02 | 0' 903 | 0' 5076350 | 200 | 9 | 1128 | 517 | 48 | 0' 5074848 |
| 140 | 0 55 | 35' 105 | | 3' 40 | 20 | 23' 04 | 0' 02 | 0' 902 | 0' 5072243 | 200 | 11 | 1129 | 547 | 48 | 0' 5070708 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072362 |
| 22-23 March, 1906. | | | | | | | | | | | | | | | |
| 140 | 9 56 | 35' 114 | - | 3' 40 | 19 | 22' 68 | +0' 04 | 0' 903 | 0' 5072223 | + 200 | -10 | -1111 | - 547 | -48 | 0' 5070707 |
| 138 | 10 57 | 33' 249 | | 3' 40 | 19 | 22' 73 | 0' 04 | 0' 902 | 0' 5076340 | 200 | 10 | 1114 | 516 | 48 | 0' 5074852 |
| 139 | 11 55 | 34' 761 | | 3' 40 | 20 | 22' 77 | 0' 04 | 0' 900 | 0' 5072970 | 200 | 11 | 1116 | 545 | 48 | 0' 5071450 |
| 137 | 12 52 | 34' 301 | | 3' 40 | 20 | 22' 79 | 0' 04 | 0' 899 | 0' 5073961 | 200 | 11 | 1117 | 534 | 48 | 0' 5072451 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072365 |
| 140 | 22 5 | 35' 100 | - | 3' 40 | 18 | 22' 77 | +0' 10 | 0' 902 | 0' 5072252 | + 200 | -9 | -1116 | - 547 | -48 | 0' 5070732 |
| 138 | 23 3 | 33' 236 | | 3' 40 | 19 | 22' 90 | 0' 10 | 0' 900 | 0' 5076370 | 200 | 10 | 1122 | 515 | 48 | 0' 5074875 |
| 139 | 0 6 | 34' 746 | | 3' 40 | 18 | 22' 99 | 0' 10 | 0' 900 | 0' 5073000 | 200 | 9 | 1127 | 545 | 48 | 0' 5071471 |
| 137 | 1 3 | 34' 288 | | 3' 40 | 19 | 23' 07 | 0' 10 | 0' 899 | 0' 5073991 | 200 | 10 | 1130 | 534 | 48 | 0' 5072469 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072387 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072369 |
| | | | | | | | | | | | | | (Mean of two sets) | | |
| 23-24 March, 1906. | | | | | | | | | | | | | | | |
| 139 | 9 55 | 34' 748 | - | 2' 72 | 19 | 22' 79 | 0' 00 | 0' 899 | 0' 5072998 | + 160 | -10 | -1117 | - 545 | -48 | 0' 5071438 |
| 137 | 10 54 | 34' 291 | | 2' 72 | 19 | 22' 85 | 0' 00 | 0' 899 | 0' 5073985 | 160 | 10 | 1120 | 534 | 48 | 0' 5072433 |
| 140 | 11 48 | 35' 095 | | 2' 72 | 19 | 22' 79 | 0' 00 | 0' 899 | 0' 5072266 | 160 | 10 | 1117 | 545 | 48 | 0' 5070706 |
| 138 | 12 47 | 33' 232 | | 2' 72 | 19 | 22' 84 | 0' 00 | 0' 899 | 0' 5076377 | 160 | 10 | 1119 | 514 | 48 | 0' 5074846 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072356 |
| 139 | 22 2 | 34' 747 | - | 2' 72 | 18 | 22' 78 | +0' 11 | 0' 902 | 0' 5072999 | + 160 | -9 | -1116 | - 547 | -48 | 0' 5071439 |
| 137 | 23 4 | 34' 288 | | 2' 72 | 18 | 22' 91 | 0' 11 | 0' 902 | 0' 5073990 | 160 | 9 | 1123 | 536 | 48 | 0' 5072434 |
| 140 | 0 5 | 35' 091 | | 2' 72 | 18 | 23' 02 | 0' 11 | 0' 902 | 0' 5072273 | 160 | 9 | 1128 | 547 | 48 | 0' 5070701 |
| 138 | 1 5 | 33' 230 | | 2' 72 | 19 | 23' 09 | 0' 11 | 0' 900 | 0' 5076383 | 160 | 10 | 1131 | 515 | 48 | 0' 5074839 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072353 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072355 |
| 24-25 March, 1906. | | | | | | | | | | | | | | | |
| 138 | 9 2 | 33' 239 | - | 2' 72 | 18 | 22' 59 | +0' 04 | 0' 903 | 0' 5076361 | + 160 | -9 | -1107 | - 517 | -48 | 0' 5074840 |
| 140 | 9 59 | 35' 099 | | 2' 72 | 19 | 22' 73 | 0' 04 | 0' 904 | 0' 5072257 | 160 | 10 | 1114 | 548 | 48 | 0' 5070697 |
| 137 | 11 1 | 34' 290 | | 2' 72 | 18 | 22' 73 | 0' 04 | 0' 904 | 0' 5073986 | 160 | 9 | 1114 | 537 | 48 | 0' 5072438 |
| 139 | 11 58 | 34' 747 | | 2' 72 | 18 | 22' 72 | 0' 04 | 0' 904 | 0' 5072999 | 160 | 9 | 1113 | 548 | 48 | 0' 5071441 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072354 |
| 138 | 21 20 | 33' 235 | - | 2' 72 | 18 | 22' 54 | +0' 15 | 0' 906 | 0' 5076371 | + 160 | -9 | -1104 | - 518 | -48 | 0' 5074852 |
| 140 | 22 41 | 35' 092 | | 2' 72 | 16 | 22' 74 | 0' 15 | 0' 906 | 0' 5072270 | 160 | 7 | 1114 | 549 | 48 | 0' 5070712 |
| 137 | 23 27 | 34' 287 | | 2' 72 | 19 | 22' 84 | 0' 15 | 0' 905 | 0' 5073993 | 160 | 10 | 1119 | 538 | 48 | 0' 5072438 |
| 139 | 0 21 | 34' 738 | | 2' 72 | 19 | 22' 96 | 0' 15 | 0' 904 | 0' 5073017 | 160 | 10 | 1125 | 548 | 48 | 0' 5071446 |
| | | | | | | | | | | | | | Mean | ... | 0' 5072362 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|------------------------------------|-----------|---------------------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | |
| 25-26 March, 1906. | | | | | | | | | | | | | | | |
| 139 | 9 4 | 34'736 | - 2'72 | 18 | 22°51 | + 0°03 | 0'906 | 0'5073022 | + 160 | - 9 | - 1103 | - 549 | - 48 | 0'5071473 | |
| 137 | 10 2 | 34'282 | 2'72 | 18 | 22°59 | 0°03 | 0'906 | 0'5074005 | 160 | 9 | 1107 | 538 | 48 | 0'5072463 | |
| 140 | 11 4 | 35°097 | 2'72 | 18 | 22°61 | 0°03 | 0'906 | 0'5072260 | 160 | 9 | 1108 | 549 | 48 | 0'5070706 | |
| 138 | 12 5 | 33'229 | 2'72 | 20 | 22°62 | 0°03 | 0'905 | 0'5076386 | 160 | 11 | 1108 | 518 | 48 | 0'5074861 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072376 |
| 139 | 21 14 | 34'727 | - 2'72 | 18 | 22°98 | + 0°06 | 0'905 | 0'5073042 | + 160 | - 9 | - 1126 | - 548 | - 48 | 0'5071471 | |
| 137 | 22 17 | 34'271 | 2'72 | 19 | 23°08 | 0°06 | 0'905 | 0'5074029 | 160 | 10 | 1131 | 538 | 48 | 0'5072462 | |
| 140 | 23 16 | 35°071 | 2'72 | 18 | 23°14 | 0°06 | 0'905 | 0'5072315 | 160 | 9 | 1134 | 548 | 48 | 0'5070736 | |
| 138 | 0 18 | 33'214 | 2'72 | 19 | 23°13 | 0°06 | 0'904 | 0'5076421 | 160 | 10 | 1133 | 517 | 48 | 0'5074873 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072385 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0'5072364 |
| | | | | | | | | | | | | | (Mean of three sets) | | |
| | | | | | | | | | | | | | General Mean | ... | 0'5072367 |
| Mach. | | | | | | | | | | | | | | | |
| 29-30 March, 1906. | | | | | | | | | | | | | | | |
| 137 | 9 32 | 34°019 | + 5'93 | 19 | 17°18 | + 0°09 | 0'828 | 0'5074583 | - 348 | - 10 | - 842 | - 492 | - 39 | 0'5072852 | |
| 139 | 10 32 | 34°469 | 5'93 | 20 | 17°34 | 0°09 | 0'828 | 0'5073596 | 348 | 11 | 850 | 502 | 39 | 0'5071846 | |
| 138 | 11 30 | 32°981 | 5'93 | 19 | 17°42 | 0°09 | 0'826 | 0'5076970 | 348 | 10 | 854 | 472 | 39 | 0'5075247 | |
| 140 | 12 31 | 34°812 | 5'93 | 19 | 17°43 | 0°09 | 0'826 | 0'5072861 | 348 | 10 | 854 | 501 | 39 | 0'5071109 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072764 |
| 137 | 21 30 | 34°011 | + 5'93 | 18 | 17°31 | 0°00 | 0'827 | 0'5074602 | - 348 | - 9 | - 848 | - 491 | - 39 | 0'5072867 | |
| 139 | 22 32 | 34°461 | 5'93 | 18 | 17°34 | 0°00 | 0'827 | 0'5073612 | 348 | 9 | 850 | 501 | 39 | 0'5071865 | |
| 138 | 23 32 | 32°971 | 5'93 | 19 | 17°33 | 0°00 | 0'827 | 0'5076991 | 348 | 10 | 849 | 473 | 39 | 0'5075272 | |
| 140 | 0 31 | 34°804 | 5'93 | 18 | 17°33 | 0°00 | 0'825 | 0'5072878 | 348 | 9 | 849 | 500 | 39 | 0'5071133 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072784 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0'5072774 |
| 30-31 March, 1906. | | | | | | | | | | | | | | | |
| 140 | 9 25 | 34°804 | + 6'24 | 18 | 17°35 | - 0°07 | 0'823 | 0'5072878 | - 366 | - 9 | - 850 | - 499 | - 39 | 0'5071115 | |
| 138 | 10 26 | 32°973 | 6'24 | 19 | 17°41 | 0°07 | 0'823 | 0'5076988 | 366 | 10 | 853 | 471 | 39 | 0'5075249 | |
| 139 | 11 24 | 34°460 | 6'24 | 19 | 17°34 | 0°07 | 0'824 | 0'5073617 | 366 | 10 | 850 | 490 | 39 | 0'5071853 | |
| 137 | 12 23 | 34°016 | 6'24 | 19 | 17°16 | 0°07 | 0'824 | 0'5074589 | 366 | 10 | 841 | 489 | 39 | 0'5072844 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072765 |
| 140 | 21 31 | 34°794 | + 6'24 | 18 | 17°06 | + 0°05 | 0'825 | 0'5072900 | - 366 | - 9 | - 836 | - 500 | - 39 | 0'5071150 | |
| 138 | 22 33 | 32°962 | 6'24 | 18 | 17°10 | 0°05 | 0'825 | 0'5077011 | 366 | 9 | 838 | 472 | 39 | 0'5075287 | |
| 139 | 23 30 | 34°449 | 6'24 | 19 | 17°14 | 0°05 | 0'825 | 0'5073641 | 366 | 10 | 840 | 500 | 39 | 0'5071886 | |
| 137 | 0 34 | 34°001 | 6'24 | 19 | 17°20 | 0°05 | 0'825 | 0'5074625 | 366 | 10 | 843 | 490 | 39 | 0'5072877 | |
| | | | | | | | | | | | | | Mean | ... | 0'5072800 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0'5072783 |
| | | | | | | | | | | | | | General Mean | ... | 0'5072779 |
| Quetta. | | | | | | | | | | | | | | | |
| 3-4 April, 1906. | | | | | | | | | | | | | | | |
| 137 | 9 57 | 34°009 | + 3'36 | 19 | 15°51 | 0°00 | 0'773 | 0'5074607 | - 197 | - 10 | - 760 | - 459 | - 43 | 0'5073138 | |
| 139 | 10 57 | 34°458 | 3'36 | 20 | 15°49 | 0°00 | 0'773 | 0'5073622 | 197 | 11 | 759 | 468 | 43 | 0'5072144 | |
| 138 | 11 50 | 32°967 | 3'36 | 20 | 15°50 | 0°00 | 0'773 | 0'5077001 | 197 | 11 | 760 | 442 | 43 | 0'5075548 | |
| 140 | 12 46 | 34°800 | 3'36 | 19 | 15°49 | 0°00 | 0'773 | 0'5072885 | 197 | 10 | 759 | 468 | 43 | 0'5071408 | |
| | | | | | | | | | | | | | Mean | ... | 0'5073059 |
| 137 | 21 49 | 34°006 | + 3'36 | 19 | 15°37 | + 0°19 | 0'773 | 0'5074613 | - 197 | - 10 | - 753 | - 459 | - 43 | 0'5073151 | |
| 139 | 22 51 | 34°457 | 3'36 | 18 | 15°55 | 0°19 | 0'772 | 0'5073622 | 197 | 9 | 762 | 468 | 43 | 0'5072143 | |
| 138 | 23 51 | 32°963 | 3'36 | 19 | 15°71 | 0°19 | 0'772 | 0'5077011 | 197 | 10 | 770 | 442 | 43 | 0'5075549 | |
| 140 | 0 49 | 34°787 | 3'36 | 18 | 15°92 | 0°19 | 0'772 | 0'5072915 | 197 | 9 | 780 | 468 | 43 | 0'5071418 | |
| | | | | | | | | | | | | | Mean | ... | 0'5073065 |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0'5073062 |

Table I. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|----------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|------------------------------------|---------------------------|------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 4-5 April, 1906. | | | | | | | | | | | | | | | | |
| 140 | 9 58 | 34' 780 | + | 3' 86 | 19 | 15' 99 | 0' 00 | 0' 770 | 0' 5072929 | - | 227 | -10 | -784 | -467 | -43 | 0' 5071398 |
| 138 | 10 56 | 32' 947 | | 3' 86 | 20 | 16' 02 | 0' 00 | 0' 770 | 0' 5077049 | | 227 | 11 | 785 | 440 | 43 | 0' 5075543 |
| 139 | 11 54 | 34' 432 | | 3' 86 | 19 | 16' 01 | 0' 00 | 0' 769 | 0' 5073678 | | 227 | 10 | 784 | 466 | 43 | 0' 5072148 |
| 137 | 12 51 | 33' 985 | | 3' 86 | 19 | 16' 00 | 0' 00 | 0' 769 | 0' 5074661 | | 227 | 10 | 784 | 457 | 43 | 0' 5073140 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5073057 |
| 140 | 21 52 | 34' 773 | + | 3' 86 | 18 | 16' 23 | +0' 10 | 0' 770 | 0' 5072945 | - | 227 | -9 | -795 | -467 | -43 | 0' 5071404 |
| 138 | 22 54 | 32' 941 | | 3' 86 | 19 | 16' 27 | 0' 10 | 0' 770 | 0' 5077062 | | 227 | 10 | 797 | 440 | 43 | 0' 5075545 |
| 139 | 23 53 | 34' 426 | | 3' 86 | 19 | 16' 37 | 0' 10 | 0' 769 | 0' 5073688 | | 227 | 10 | 802 | 466 | 43 | 0' 5072140 |
| 137 | 0 54 | 33' 976 | | 3' 86 | 19 | 16' 50 | 0' 10 | 0' 769 | 0' 5074680 | | 227 | 10 | 809 | 457 | 43 | 0' 5073134 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5073056 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5073057 |
| 5-6 April, 1906. | | | | | | | | | | | | | | | | |
| 139 | 10 20 | 34' 401 | + | 4' 30 | 19 | 16' 77 | -0' 06 | 0' 767 | 0' 5073745 | - | 252 | -10 | -822 | -465 | -43 | 0' 5072153 |
| 137 | 11 18 | 33' 955 | | 4' 30 | 18 | 16' 77 | 0' 06 | 0' 767 | 0' 5074728 | | 252 | 9 | 822 | 456 | 43 | 0' 5073146 |
| 140 | 12 12 | 34' 749 | | 4' 30 | 18 | 16' 70 | 0' 06 | 0' 767 | 0' 5072995 | | 252 | 9 | 818 | 465 | 43 | 0' 5071408 |
| 138 | 13 11 | 32' 921 | | 4' 30 | 19 | 16' 60 | 0' 06 | 0' 768 | 0' 5077110 | | 252 | 10 | 813 | 439 | 43 | 0' 5075553 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5073065 |
| 139 | 22 24 | 34' 395 | + | 4' 30 | 18 | 16' 90 | +0' 16 | 0' 768 | 0' 5073758 | - | 252 | -9 | -828 | -465 | -43 | 0' 5072161 |
| 137 | 23 25 | 33' 950 | | 4' 30 | 19 | 17' 08 | 0' 16 | 0' 767 | 0' 5074740 | | 252 | 10 | 837 | 456 | 43 | 0' 5073142 |
| 140 | 0 24 | 34' 741 | | 4' 30 | 19 | 17' 21 | 0' 16 | 0' 766 | 0' 5073011 | | 252 | 10 | 843 | 464 | 43 | 0' 5071399 |
| 138 | 1 22 | 32' 907 | | 4' 30 | 19 | 17' 38 | 0' 16 | 0' 765 | 0' 5077143 | | 252 | 10 | 852 | 438 | 43 | 0' 5075548 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5073063 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5073064 |
| | | | | | | | | | | | | | | General Mean | ... | 0' 5073061 |
| Dehra Dun—(Pendulum room). | | | | | | | | | | | | | | | | |
| 21-22 April, 1906. | | | | | | | | | | | | | | | | |
| 137 | 11 56 | 33' 708 | + | 14' 76 | 17 | 26' 03 | -0' 15 | 0' 837 | 0' 5075283 | - | 866 | -8 | -1275 | -497 | -39 | 0' 5072598 |
| 139 | 12 56 | 34' 151 | | 14' 76 | 17 | 25' 83 | 0' 15 | 0' 838 | 0' 5074290 | | 866 | 8 | 1266 | 508 | 39 | 0' 5071603 |
| 138 | 13 55 | 32' 693 | | 14' 76 | 18 | 25' 71 | 0' 15 | 0' 838 | 0' 5077656 | | 866 | 9 | 1260 | 479 | 39 | 0' 5075003 |
| 140 | 14 56 | 34' 500 | | 14' 76 | 17 | 25' 57 | 0' 15 | 0' 839 | 0' 5073530 | | 866 | 8 | 1253 | 508 | 39 | 0' 5070856 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5072515 |
| 137 | 23 59 | 33' 708 | + | 14' 76 | 16 | 25' 81 | +0' 12 | 0' 835 | 0' 5075283 | - | 866 | -7 | -1265 | -496 | -39 | 0' 5072610 |
| 139 | 0 59 | 34' 150 | | 14' 76 | 19 | 25' 97 | 0' 12 | 0' 834 | 0' 5074292 | | 866 | 10 | 1273 | 505 | 39 | 0' 5071599 |
| 138 | 2 0 | 32' 687 | | 14' 76 | 16 | 26' 08 | 0' 12 | 0' 834 | 0' 5077672 | | 866 | 7 | 1278 | 477 | 39 | 0' 5075005 |
| 140 | 3 0 | 34' 483 | | 14' 76 | 17 | 26' 17 | 0' 12 | 0' 833 | 0' 5073568 | | 866 | 8 | 1282 | 505 | 39 | 0' 5070868 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5072521 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072518 |
| 22-23 April, 1906. | | | | | | | | | | | | | | | | |
| 140 | 11 52 | 34' 473 | + | 15' 10 | 17 | 26' 18 | -0' 09 | 0' 836 | 0' 5073587 | - | 886 | -8 | -1283 | -507 | -39 | 0' 5070864 |
| 138 | 12 52 | 32' 679 | | 15' 10 | 18 | 25' 92 | 0' 09 | 0' 837 | 0' 5077691 | | 886 | 9 | 1270 | 479 | 39 | 0' 5075008 |
| 139 | 13 51 | 34' 143 | | 15' 10 | 16 | 25' 88 | 0' 09 | 0' 837 | 0' 5074309 | | 886 | 7 | 1268 | 507 | 39 | 0' 5071602 |
| 137 | 14 51 | 33' 707 | | 15' 10 | 17 | 25' 85 | 0' 09 | 0' 835 | 0' 5075286 | | 886 | 8 | 1267 | 496 | 39 | 0' 5072590 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5072516 |
| 140 | 0 13 | 34' 484 | + | 15' 10 | 17 | 26' 03 | +0' 11 | 0' 834 | 0' 5073563 | - | 886 | -8 | -1275 | -505 | -39 | 0' 5070850 |
| 138 | 1 12 | 32' 682 | | 15' 10 | 17 | 26' 18 | 0' 11 | 0' 834 | 0' 5077683 | | 886 | 8 | 1283 | 477 | 39 | 0' 5074990 |
| 139 | 2 13 | 34' 140 | | 15' 10 | 17 | 26' 29 | 0' 11 | 0' 834 | 0' 5074316 | | 886 | 8 | 1288 | 505 | 39 | 0' 5071590 |
| 137 | 3 12 | 33' 695 | | 15' 10 | 18 | 26' 37 | 0' 11 | 0' 832 | 0' 5075312 | | 886 | 9 | 1292 | 494 | 39 | 0' 5072592 |
| | | | | | | | | | | | | | | Mean | ... | 0' 5072506 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0' 5072511 |

TIME OF VIBRATION AT DEHRA DUN.

In Table II the times of vibration of each pendulum in November and April respectively are collected.

Table II.—Times of Vibration at Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|-----------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| <i>November 1905.</i> | | | | | |
| Nov. 12—13 | ^s 0·5072577 | ^s 0·5074989 | ^s 0·5071600 | ^s 0·5070856 | ^s 0·5072505 |
| „ 13—14 | 2577 | 4981 | 1590 | 0849 | 2499 |
| „ 14—15 | 2596 | 5001 | 1603 | 0857 | 2514 |
| Mean | 0·5072583 | 0·5074990 | 0·5071598 | 0·5070854 | 0·5072506 |
| <i>April 1906.</i> | | | | | |
| April 21—22 | 0·5072604 | 0·5075004 | 0·5071601 | 0·5070862 | 0·5072518 |
| „ 22—23 | 2591 | 4999 | 1596 | 0857 | 2511 |
| „ 23—24 | 2597 | 4997 | 1602 | 0860 | 2514 |
| „ 24—25 | 2601 | 5005 | 1598 | 0862 | 2516 |
| Mean | 0·5072598 | 0·5075001 | 0·5071599 | 0·5070860 | 0·5072515 |
| Change, April—Nov. | + 15 | + 11 | + 1 | + 6 | + 9 |

The agreement between the November and April values is more satisfactory than in the preceding season; it will nevertheless be desirable to examine the differences between the individual pendulums and the mean pendulum in the same way as was done in Table III of Chap. III.

These differences are shewn in Table III for each set, and in Table IV the means for each station are given.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

| Station | Date | 137 | ∇ | 138 | ∇ | 139 | ∇ | 140 | ∇ |
|---------------------|-------------|------|------|--------|------|-------|------|--------|-----|
| Dehra Dun ... | 1905-06 | | | | | | | | |
| | Nov. 12-13 | - 72 | + 7 | - 2484 | + 4 | + 905 | - 6 | + 1649 | - 6 |
| | " 13-14 | 78 | 1 | 2482 | 6 | 909 | 2 | 1650 | 5 |
| | " 14-15 | 82 | - 3 | 2487 | 1 | 911 | 0 | 1657 | + 2 |
| Simla ... | Dec. 15-16 | 74 | + 5 | 2487 | + 1 | 906 | - 5 | 1655 | 0 |
| | " 16-17 | 78 | 1 | 2488 | 0 | 908 | 3 | 1657 | + 2 |
| | " 17-18 | 78 | 1 | 2490 | - 2 | 909 | 2 | 1659 | 4 |
| | | | | | | | | | |
| Kálka ... | Dec. 22-23 | 81 | - 2 | 2500 | - 12 | 925 | + 14 | 1656 | + 1 |
| Ludhiána ... | Dec. 30-31 | 81 | - 2 | 2489 | - 1 | 908 | - 3 | 1662 | + 7 |
| | " 31-Jan. 1 | 69 | + 10 | 2495 | 7 | 907 | 4 | 1656 | 1 |
| | Jan. 2-3 | 77 | 2 | 2489 | 1 | 904 | 7 | 1662 | 7 |
| | " 3-4 | 67 | 12 | 2491 | 3 | 905 | 6 | 1653 | - 2 |
| Mian Mir ... | Jan. 10-11 | 66 | + 13 | 2495 | - 7 | 908 | - 3 | 1654 | - 1 |
| | " 11-12 | 81 | - 2 | 2489 | 1 | 907 | 4 | 1664 | + 9 |
| | " 12-13 | 77 | + 2 | 2494 | 6 | 909 | 2 | 1661 | 6 |
| | | | | | | | | | |
| Ferozepore ... | Jan. 17-18 | 68 | + 11 | 2497 | - 9 | 912 | + 1 | 1653 | - 3 |
| | " 18-19 | 78 | 1 | 2488 | 0 | 909 | - 2 | 1657 | + 2 |
| | " 20-21 | 77 | 2 | 2490 | - 2 | 907 | 4 | 1660 | 5 |
| | | | | | | | | | |
| Pathánkot ... | Feb. 2-3 | 82 | - 3 | 2484 | + 4 | 914 | + 3 | 1651 | - 4 |
| | " 3-4 | 68 | + 11 | 2493 | - 5 | 907 | - 4 | 1655 | 0 |
| | " 4-5 | 81 | - 2 | 2478 | + 10 | 907 | 4 | 1650 | - 5 |
| | | | | | | | | | |
| Montgomery ... | Feb. 17-18 | 92 | - 13 | 2477 | + 11 | 911 | 0 | 1659 | + 4 |
| | " 18-19 | 70 | + 9 | 2495 | - 7 | 917 | + 6 | 1647 | - 8 |
| | " 19-20 | 78 | 1 | 2489 | 1 | 910 | - 1 | 1657 | + 2 |
| | | | | | | | | | |
| Dera Gházi Khan ... | Feb. 27-28 | 75 | + 4 | 2493 | - 5 | 914 | + 3 | 1652 | - 3 |
| | " 28-Mar. 1 | 86 | - 7 | 2484 | + 4 | 914 | 3 | 1654 | 1 |
| | Mar. 1-2 | 81 | 2 | 2485 | 3 | 908 | - 3 | 1656 | + 1 |
| | | | | | | | | | |
| Multán ... | Mar. 7-8 | 76 | + 3 | 2491 | - 3 | 919 | + 8 | 1649 | - 6 |
| | " 8-9 | 78 | 1 | 2496 | 8 | 915 | 4 | 1658 | + 3 |
| | " 9-10 | 84 | - 5 | 2485 | + 3 | 918 | 7 | 1653 | - 2 |
| | | | | | | | | | |
| Jacobabad ... | Mar. 15-16 | 84 | - 5 | 2490 | - 2 | 915 | + 4 | 1657 | + 2 |
| | " 16-17 | 80 | 1 | 2480 | + 8 | 892 | - 19 | 1668 | 13 |
| | " 17-18 | 77 | + 2 | 2487 | 1 | 912 | + 1 | 1653 | - 2 |
| | | | | | | | | | |
| Sibi ... | Mar. 21-22 | 80 | - 1 | 2489 | - 1 | 914 | + 3 | 1656 | + 1 |
| | " 22-23 | 84 | 5 | 2488 | 0 | 915 | 4 | 1656 | 1 |
| | " 23-24 | 79 | 0 | 2488 | 0 | 916 | 5 | 1651 | - 4 |
| | " 24-25 | 80 | - 1 | 2488 | 0 | 914 | 3 | 1653 | 2 |
| | " 25-26 | 82 | 3 | 2486 | + 2 | 909 | - 2 | 1660 | + 5 |
| | | | | | | | | | |
| Mach ... | Mar. 29-30 | 86 | - 7 | 2485 | + 3 | 918 | + 7 | 1653 | - 2 |
| | " 30-31 | 78 | + 1 | 2485 | 3 | 914 | 3 | 1650 | 5 |
| Quetta ... | Ap. 3-4 | 83 | - 4 | 2486 | + 2 | 918 | + 7 | 1649 | - 6 |
| | " 4-5 | 80 | 1 | 2487 | 1 | 913 | 2 | 1656 | + 1 |
| | " 5-6 | 80 | 1 | 2487 | 1 | 907 | - 4 | 1661 | 6 |
| | | | | | | | | | |
| Dehra Dun ... | Ap. 21-22 | 86 | - 7 | 2486 | + 2 | 917 | + 6 | 1656 | + 1 |
| | " 22-23 | 80 | 1 | 2488 | 0 | 915 | 4 | 1654 | - 1 |
| | " 23-24 | 83 | 4 | 2483 | + 5 | 912 | 1 | 1654 | 1 |
| | " 24-25 | 85 | 6 | 2489 | - 1 | 918 | 7 | 1654 | 1 |
| | | | | | | | | | |
| Mean ... | ... | 79 | ... | 2488 | ... | 911 | ... | 1655 | ... |

Table IV.—Differences between Individual Pendulums and Mean Pendulum.

| Station | Date | 137 | v | 138 | v | 139 | v | 140 | v |
|---------------------|-----------------------|------|-----|--------|------|-------|------|--------|-----|
| Dehra Dun ... | 1905-06 Nov. 12-15 | - 77 | + 2 | - 2484 | + 4 | + 908 | - 4 | + 1652 | - 3 |
| Simla ... | Dec. 15-18 | 77 | 2 | 2488 | 0 | 908 | 4 | 1657 | + 2 |
| Kálka ... | „ 22-23 | 81 | - 2 | 2500 | - 12 | 925 | + 13 | 1656 | 1 |
| Ludhiána ... | „ 30-Jan. 4 | 73 | + 6 | 2491 | 3 | 906 | - 6 | 1659 | 4 |
| Mian Mir ... | Jan. 10-13 | 75 | 4 | 2493 | 5 | 908 | 4 | 1659 | 4 |
| Ferozepore ... | „ 17-21 | 75 | 4 | 2492 | 4 | 909 | 3 | 1656 | 1 |
| Pathámkot ... | Feb. 2- 5 | 77 | 2 | 2485 | + 3 | 909 | 3 | 1652 | - 3 |
| Montgomery ... | „ 17-20 | 80 | - 1 | 2487 | 1 | 913 | + 1 | 1654 | 1 |
| Dera Gházi Khan ... | „ 27-Mar. 2 | 81 | 2 | 2487 | 1 | 912 | 0 | 1654 | 1 |
| Multán ... | March 7-10 | 79 | 0 | 2491 | - 3 | 917 | + 5 | 1653 | 2 |
| Jacobabad ... | „ 15-18 | 80 | 1 | 2485 | + 3 | 907 | - 5 | 1660 | + 5 |
| Sibi ... | „ 21-26 | 81 | 2 | 2488 | 0 | 915 | + 3 | 1655 | 0 |
| Mach ... | „ 29-31 | 82 | 3 | 2484 | + 4 | 916 | 4 | 1652 | - 3 |
| Quetta ... | April 3- 6 | 81 | 2 | 2487 | 1 | 913 | + 1 | 1655 | 0 |
| Dehra Dun ... | „ 21-25 | 83 | 4 | 2486 | 2 | 916 | + 4 | 1655 | 0 |
| Mean ... | | 79 | ... | 2488 | ... | 912 | ... | 1655 | ... |

There is no evidence of any pendulum having changed its length appreciably with reference to the mean, and a simple mean of the times of vibration at Dehra Dun, in November and April respectively, will be used for the deduction of g .

In the following table the times of vibration of each pendulum and of the mean pendulum are shewn, together with the differences from Dehra Dun and the resulting values of g . The value of g at Dehra Dun has been taken to be 979.063.

Table V.—Mean Times of Vibration and Deduced Values of g .

| Station | | 137 | 138 | 139 | 140 | Mean |
|-----------------|----|------------------|------------------|------------------|------------------|------------------|
| Dehra Dun | s. | 0.5072591 | 0.5074996 | 0.5071599 | 0.5070857 | 0.5072511 |
| Simla | s. | 0.5073165 | 0.5075576 | 0.5072180 | 0.5071431 | 0.5073088 |
| | g. | + 574 978.842 | + 580 978.839 | + 581 978.838 | + 574 978.841 | + 577 978.840 |
| Kálka | s. | 0.5072373 | 0.5074792 | 0.5071367 | 0.5070636 | 0.5072292 |
| | g. | - 218 979.147 | - 204 979.141 | - 232 979.152 | - 221 979.149 | - 219 979.147 |
| Ludhiána | s. | 0.5072038 | 0.5074456 | 0.5071059 | 0.5070306 | 0.5071965 |
| | g. | - 553 979.277 | - 540 979.271 | - 540 979.271 | - 551 979.276 | - 546 979.274 |
| Mian Mir | s. | 0.5071756 | 0.5074174 | 0.5070773 | 0.5070022 | 0.5071681 |
| | g. | - 835 979.384 | - 822 979.380 | - 826 979.382 | - 835 979.385 | - 830 979.383 |
| Ferozepore | s. | 0.5071866 | 0.5074283 | 0.5070882 | 0.5070135 | 0.5071791 |
| | g. | - 725 979.343 | - 713 979.338 | - 717 979.340 | - 722 979.342 | - 720 979.341 |
| Pathánkot | s. | 0.5072138 | 0.5074546 | 0.5071152 | 0.5070409 | 0.5072061 |
| | g. | - 453 979.238 | - 450 979.236 | - 447 979.235 | - 448 979.236 | - 450 979.237 |
| Montgomery | s. | 0.5071923 | 0.5074330 | 0.5070930 | 0.5070189 | 0.5071843 |
| | g. | - 668 979.321 | - 666 979.320 | - 669 979.321 | - 668 979.321 | - 668 979.321 |
| Dera Gházi Khan | s. | 0.5072258 | 0.5074664 | 0.5071265 | 0.5070523 | 0.5072177 |
| | g. | - 333 979.191 | - 332 979.191 | - 334 979.192 | - 334 979.192 | - 334 979.192 |
| Multán | s. | 0.5072124 | 0.5074536 | 0.5071128 | 0.5070392 | 0.5072045 |
| | g. | - 467 979.244 | - 460 979.240 | - 471 979.245 | - 465 979.242 | - 466 979.243 |
| Jacobabad | s. | 0.5072272 | 0.5074677 | 0.5071285 | 0.5070532 | 0.5072192 |
| | g. | - 319 979.186 | - 319 979.186 | - 314 979.184 | - 325 979.188 | - 319 979.186 |
| Sibi | s. | 0.5072448 | 0.5074855 | 0.5071452 | 0.5070712 | 0.5072367 |
| | g. | - 143 979.118 | - 141 979.117 | - 147 979.119 | - 145 979.119 | - 144 979.119 |
| Mach | s. | 0.5072861 | 0.5075263 | 0.5071863 | 0.5071127 | 0.5072779 |
| | g. | + 270 978.959 | + 267 978.959 | + 264 978.961 | + 270 978.959 | + 268 978.960 |
| Quetta | s. | 0.5073142 | 0.5075548 | 0.5072148 | 0.5071406 | 0.5073061 |
| | g. | + 551 978.851 | + 552 978.850 | + 549 978.851 | + 549 978.851 | + 550 978.851 |

The Reduction to Sea-level.

Orographical corrections were required for six of the stations of this season, namely for Simla, Kálka, Pathánkot, Sibi, Mach and Quetta. A different method of analysing the masses lying in the several zones was employed this year. Hitherto the zones have been cut up into more or less numerous compartments or blocks and an estimate has been made of the mean height of each block, that is to say of the height it would have if it were levelled.

By this process it was frequently necessary to imagine tremendous changes of level to take place, for a block might, and often did, contain both a lofty peak and a deep valley; I have shewn in Chapter II that all such imaginary levellings introduce error, and it was to avoid large operations of this kind that I altered the method.

Movements of masses in azimuth have, as has been pointed out, no effect on the vertical component of their attraction; if therefore a zone be divided up by contours and we measure the areas of all parts lying between the different pairs of contours, we shall be able to ascertain what fraction of the whole zone lies for instance, between 100 feet and 200 feet, 200 feet and 300 feet etc. etc. above or below the pendulum station. In this way we can collect areas of similar height in a more efficient way than by grouping blocks together as has been done hitherto. In fact by this method the zone is broken up into its component parts along natural lines, instead of by means of arbitrarily drawn radii.

It may be said that this plan can only be followed if contoured maps are available, but even if only hill-shaded maps can be had it is not more difficult to draw in approximate contours, at wide intervals, by eye than it is to estimate the mean heights of blocks; indeed in complicated country it is generally necessary to put in some contour lines before any estimate can be made. The new method has also a practical advantage in that by it only a limited number of different heights in each zone have to be dealt with: by the former method each block was likely to have a different height, so that in order to curtail the computation it was necessary to adopt some expedient involving a loss of accuracy. The advantage gained will be seen by comparing the tables of this year's computations with those of Chapter II.

Several methods of measuring the areas were tried, the one which I found most satisfactory was to draw radial lines at 5° intervals and then measure the total length of line intercepted between each pair of contours; in complicated country it proved very advantageous to draw the contours in different coloured inks so that each was instantly recognisable.

The intervals at which the contours should be drawn depend firstly on the distance of the area under consideration from the station. Up to half a mile 100 feet contours are desirable, thence up to 1 mile 200 feet, from 1 to 5 miles 500 feet, from 5 to 10 miles 1000 feet and from 10 miles to 35 miles 2000 feet. But this general rule may be modified according to the nature of the country and the kind of map that is available. In hilly country I like to have a special map on a scale of 12 inches to 1 mile for the immediate surroundings, that is to say up to a radius of about half a mile, a 4-inch to a mile map up to 2 miles, a 1-inch map to 10 miles and thence a quarter-inch map, but it is very seldom that all these are obtainable.

The following tables contain the details of all the stations considered. Hitherto the differences between the heights of the compartments and that of the station have been given in the tables, but I have preferred in this chapter to give the actual heights of the parts into which the zones have been divided.

Table VI.—Orographical Correction at Simla.

Height 7043 feet.

| No. of Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------------------------|-------------------|--------------------|-------------------|--------------------|---------------------|---------------------|---------------------|
| Inner radius Outer radius | 100 feet 200 „ | 200 feet* 400 „ | 400 feet 600 „ | 600 feet 1000 „ | 1000 feet 1500 „ | 1500 feet 2000 „ | 2000 feet 2640 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 5950 | | | | | | | 0.028 |
| 6050 | | | | | | | .054 |
| 6150 | | | | | | 0.023 | .117 |
| 6250 | | | | | | .100 | .130 |
| 6350 | | | | | 0.129 | .122 | .087 |
| 6450 | | | | 0.027 | .183 | .098 | .079 |
| 6550 | | | | .184 | .118 | .131 | .092 |
| 6650 | | | 0.102 | .352 | .136 | .110 | .071 |
| 6750 | | 0.036 | .377 | .147 | .151 | .137 | .132 |
| 6850 | | .246 | .260 | .097 | .111 | .078 | .077 |
| 6950 | | .597 | .232 | .149 | .097 | .095 | .050 |
| 6980 | 0.60 | | | | | | |
| 7000 | | .044 | .029 | .044 | | | |
| 7030 | .40 | .077 | | | .056 | .050 | .041 |
| 7100 | | | | | | | |
| 7150 | | | | | .019 | .035 | .028 |
| 7200 | | | | | | .021 | .014 |
| Effect | 5.9 | 16.6 | 19.9 | 34.4 | 28.0 | 18.3 | 21.2 |

*Table VI.—Orographical Correction at Simla—(Continued).
Height 7043 feet.*

| No. of Zone | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------------|---------------------------------------|---------------------------|------------------------------|-----------------------------|------------------|------------------|------------------|
| Inner radius Outer radius | $\frac{1}{2}$ mile $\frac{3}{4}$ „ | $\frac{3}{4}$ mile 1 „ | 1 mile $1\frac{1}{2}$ „ | $1\frac{1}{2}$ miles 2 „ | 2 miles 3 „ | 3 miles 4 „ | 4 miles 5 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 4250 | | | | | | . | 0.15 |
| 4750 | | | | 0.02 | 0.05 | 0.20 | .18 |
| 5250 | | | 0.13 | .09 | .22 | .24 | .18 |
| 5750 | 0.14 | 0.26 | .23 | .20 | .32 | .28 | .17 |
| 6250 | .44 | .38 | .22 | .26 | .30 | .19 | .12 |
| 6750 | .36 | .27 | .23 | .29 | .05 | .05 | .06 |
| 7250 | .06 | .09 | .14 | .14 | .06 | .03 | .09 |
| 7750 | | | .05 | | | .01 | .05 |
| Effect | 30.9 | 21.0 | 30.2 | 14.1 | 26.5 | 19.2 | 14.7 |
| No. of Zone | 15 | 16 | No. of Zone | 17 | 18 | 19 | 20 |
| Inner radius Outer radius | 5 miles 7 „ | 7 miles 10 „ | Inner radius Outer radius | 10 miles 15 „ | 15 miles 20 „ | 20 miles 25 „ | 25 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 2500 | | 0.04 | <i>feet</i> 1000 | | | | 0.02 |
| 3500 | 0.06 | .19 | 2000 | 0.16 | 0.12 | 0.26 | .39 |
| 4500 | .38 | .30 | 4000 | .54 | .44 | .28 | .16 |
| 5500 | .30 | .19 | 6000 | .24 | .34 | .19 | .21 |
| 6500 | .15 | .18 | 8000 | .06 | .10 | .22 | .18 |
| 7500 | .08 | .08 | 10000 | | | .05 | .04 |
| 8500 | .03 | .02 | | | | | |
| Effect | 21.1 | 22.6 | Effect | 28.6 | 11.9 | 9.4 | 13.2 |

Total effect of zones up to a radius of 35 miles = 407.7
Attraction ... = 407.7 \times 0.000035 = 0.0143

For the region lying beyond the 35-mile radius we may assume that half is at a constant level of 1000 feet, and that the other half may be divided into 3 portions, namely a quadrant from north to east at an elevation of 10000 feet, a sector from north to 60° west of north at 6000 feet and a sector from east to 30° south of east also at 6000 feet.

The difference between the attraction of these masses and that of the infinite plain at the height of the station, outside the 35-mile radius, is

$$0.000035 \left(\frac{1}{35 \times 5280} \right) \cdot \frac{1}{2} \cdot \left\{ 6000^2 \times \frac{1}{2} + 3000^2 \times \frac{1}{4} + 1000^2 \times \frac{1}{4} \right\}$$

$$= 0.00194$$

The total orographical correction is therefore

$$0.0143 + 0.0019 = 0.0162.$$

*Table VII.—Orographical Correction at Kálka.
Height 2202 feet.*

| No of Zone | 1 | 2 | 3 | No. of Zone | 4 | 5 | 6 | 7 |
|------------------------------|---------------------|---------------------|---------------------------------------|------------------------------|---------------------------|-------------------|-----------------|-----------------|
| Inner Radius Outer Radius | 1500 feet 2000 „ | 2000 feet 2640 „ | $\frac{1}{2}$ mile $\frac{3}{4}$ „ | Inner Radius Outer Radius | $\frac{3}{4}$ mile 1 „ | 1 mile 2 miles | 2 miles 3 „ | 3 miles 4 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> | | | | <i>feet</i> | | | | |
| | | | | 1750 | | | 0.38 | 0.44 |
| | | | | 1950 | 0.01 | | | |
| | | | | 2000 | 0.01 | 0.59 | | |
| 2200 | 0.75 | 0.75 | 0.75 | 2200 | 0.67 | | 0.09 | 0.07 |
| 2400 | 0.25 | | 0.13 | 2350 | 0.03 | 0.13 | 0.11 | 0.04 |
| 2525 | | 0.25 | | 2450 | 0.12 | | | |
| 2700 | | | 0.12 | 2550 | 0.09 | | | |
| | | | | 2650 | 0.07 | | | |
| | | | | 2750 | | 0.21 | 0.09 | 0.06 |
| | | | | 3500 | | 0.07 | 0.25 | 0.17 |
| | | | | 4500 | | | 0.08 | 0.15 |
| | | | | 5500 | | | | 0.07 |
| Effect | 0.75 | 1.50 | 2.31 | Effect | 0.99 | 9.92 | 15.19 | 14.86 |

Table VII.—Orographical Correction at Kálka—(Continued).

Height 2202 feet.

| No. of Zone | 8 | 9 | 10 | No. of Zone | 11 | 12 | 13 | 14 |
|------------------------------|-----------------|-----------------|-----------------|------------------------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 4 miles 5 " | 5 miles 7 " | 7 miles 10 " | Inner Radius Outer Radius | 10 miles 15 " | 15 miles 20 " | 20 miles 25 " | 25 miles 35 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1400 | | 0.19 | 0.27 | <i>feet</i> 900 | 0.16 | 0.28 | 0.32 | 0.38 |
| 1800 | 0.38 | .31 | .21 | 1200 | .27 | .17 | .14 | .11 |
| 2200 | .17 | .03 | .05 | 1800 | .05 | .03 | .05 | .06 |
| 2800 | .05 | .07 | .09 | 2600 | .09 | .12 | .09 | .10 |
| 3500 | .19 | .16 | .16 | 4000 | .33 | .33 | .21 | .17 |
| 4500 | .15 | .20 | .15 | 6000 | .10 | .07 | .17 | .10 |
| 5500 | .06 | .04 | .07 | 8000 | | | .02 | .07 |
| | | | | 10000 | | | | .01 |
| Effect | 8.8 | 10.7 | 8.4 | Effect | 9.6 | 4.4 | 4.3 | 6.0 |

Total effect of zones within 35-mile radius = 97.7

Attraction = $97.7 \times 0.000035 = 0.0034$

The outer zones may be divided into four sectors:—

| Sector | Angle | Height <i>feet.</i> |
|--------|-------|------------------------|
| 1. | 220° | 1000 |
| 2. | 20 | 4000 |
| 3. | 90 | 7000 |
| 4. | 30 | 4000 |

The addition to the orographical correction on their account amounts to 0.0007.

The total orographical correction is therefore $0.0034 + 0.0007 = 0.0041$.

*Table VIII.—Orographical Correction at Pathánkot.
Height 1088 feet.*

| No. of Zone | 1 | 2 | 3 | 4 | 5 | 6 |
|------------------------------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 8 miles 12 „ | 12 miles 16 „ | 16 miles 20 „ | 20 miles 25 „ | 25 miles 30 „ | 30 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1100 | 0.85 | 0.75 | 0.66 | 0.65 | 0.62 | 0.60 |
| 2300 | .15 | .25 | | | | |
| 3000 | | | .32 | .20 | .15 | .12 |
| 4000 | | | .02 | | | |
| 5000 | | | | .13 | .10 | .11 |
| 7000 | | | | .02 | .10 | .12 |
| 9000 | | | | | .03 | .05 |
| Effect | 0.9 | 0.7 | 1.6 | 3.2 | 4.9 | 3.6 |

Total effect of zones within 35-mile radius = 14.9

Attraction = $14.9 \times 0.000035 = 0.0005$

Beyond the 35-mile radius the zones may be divided into 4 sectors:—

| Sector | Angle | Height <i>feet.</i> |
|--------|-------|------------------------|
| 1. | 180 | 1100 |
| 2. | 45 | 5000 |
| 3. | 90 | 8000 |
| 4. | 45 | 3000 |

The addition to the orographical correction on account of the outer zones is therefore
0.0014

And the total orographical correction becomes $0.0005 + 0.0014 = 0.0019$

Table IX.—Orographical Correction at Sibi.

Height 434 feet.

| No. of Zone | 1 | 2 | 3 | 4 | 5 |
|--------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 7 miles | 10 miles | 15 miles | 20 miles | 25 miles |
| Outer Radius | 10 „ | 15 „ | 20 „ | 25 „ | 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 450 | 0.88 | 0.62 | 0.49 | 0.30 | 0.25 |
| 750 | .12 | .22 | .25 | .28 | .12 |
| 1550 | | .16 | .22 | .34 | .28 |
| 2250 | | | .04 | | |
| 2450 | | | | .08 | .24 |
| 3550 | | | | | .08 |
| 4450 | | | | | .03 |
| Effect | 0 | 0.7 | 0.7 | 0.7 | 2.7 |

Total effect of zones within 35-mile radius = 4.8

Attraction = $4.8 \times 0.000035 = 0.0002$

The outer zones contain much higher hills and table-lands than come within the 35-mile circle. The region may be divided up into 4 sectors:—

| Sector | Angle | Height <i>feet.</i> |
|--------------------------------|-------|------------------------|
| 1. From North to East, | 90 | 4500 |
| 2. From East to S.E., | 45 | 2000 |
| 3. From S.E. to 30° W. of S., | 75 | 450 |
| 4. From 30° W. of S. to North, | 150 | 5500 |

The attraction of the masses lying above the 450-foot plain outside the 35-mile circle is
0.0014

Hence the total orographical correction = $0.0014 + 0.0002 = 0.0016$

*Table X.—Orographical Correction at Mach.
Height 3522 feet.*

| No. of Zone | 1 | 2 | 3 | 4 | No. of Zone | 5 | 6 | 7 |
|------------------------------|---------------------|-------------------|-----------------|-----------------|------------------------------|-----------------|------------------|------------------|
| Inner Radius Outer Radius | 1000 feet 5280 „ | 1 mile 2 miles | 2 miles 4 „ | 4 miles 7 „ | Inner Radius Outer Radius | 7 miles 10 „ | 10 miles 15 „ | 15 miles 20 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 2200 | | | | 0.05 | <i>feet</i> 1500 | 0.05 | 0.12 | 0.13 |
| 2700 | | | | .11 | 2700 | | .16 | |
| 2800 | | | | .07 | 2800 | .22 | | .24 |
| 2900 | | 0.13 | 0.16 | | 4500 | .24 | .20 | .09 |
| 3200 | | .45 | .18 | | 5800 | | | .23 |
| 3300 | 0.5 | | | .14 | 6000 | | .22 | |
| 3700 | .5 | | .24 | | 6500 | .37 | .21 | .26 |
| 3800 | | .42 | | | 8000 | | .04 | |
| 4500 | | | | .20 | 8500 | .12 | .05 | .05 |
| 4800 | | | .30 | | | | | |
| 5700 | | | | .24 | | | | |
| 6000 | | | .12 | | | | | |
| 6800 | | | | .17 | | | | |
| 7700 | | | | .02 | | | | |
| Effect | 16.2 | 6.0 | 31.7 | 38.1 | Effect | 28.0 | 19.1 | 8.9 |

Table X.—Orographical Correction at Mach.—(Continued).
Height 3522 feet.

| No. of Zone | 8 | 9 | 10 |
|------------------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 20 miles 25 „ | 25 miles 30 „ | 30 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 800 | 0.03 | 0.13 | 0.14 |
| 1500 | .17 | .09 | .11 |
| 2700 | .19 | .12 | .06 |
| 4500 | .06 | .13 | .16 |
| 5200 | ... | .04 | .13 |
| 6200 | .39 | .33 | .28 |
| 8000 | .03 | .12 | .10 |
| 8500 | .11 | ... | ... |
| 10000 | .02 | .04 | .02 |
| Effect | 7.7 | 5.4 | 2.6 |

Total effect of zones within 35-mile radius = 163.7
 Attraction = $163.7 \times 0.000035 = 0.0057$

The region lying beyond the 35-mile circle may be divided into six sectors:—

| Sector | Angle | Height <i>feet</i> |
|--------------------------|-------|-----------------------|
| 1. N. to N. E. | 45 | 6000 |
| 2. N. E. to 35° S. of E. | 80 | 3000 |
| 3. 35° S. of E. to S. | 55 | 300 |
| 4. S. to S. W. | 45 | 6000 |
| 5. S. W. to W. | 45 | 4000 |
| 6. W. to N. | 90 | 5000 |

The orographical correction on account of the outer zones is
 0.00036

And the total orographical correction is $0.0057 + .0004 = 0.0061$

*Table XI.—Orographical Correction at Quetta.
Height 5520 feet.*

| No. of Zone | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 2 miles | 3 miles | 4 miles | 5 miles | 6 miles | 7 miles |
| Outer Radius | 3 " | 4 " | 5 " | 6 " | 7 " | 10 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 5500 | 0.89 | 0.76 | 0.51 | 0.28 | 0.31 | 0.16 |
| 5800 | ... | .08 | .12 | .21 | .15 | ... |
| 6300 | ... | ... | ... | ... | ... | .59 |
| 6500 | 0.11 | .07 | .19 | .22 | .28 | ... |
| 7500 | ... | .07 | .12 | .16 | .14 | ... |
| 8000 | ... | ... | ... | ... | ... | .25 |
| 8500 | ... | .02 | .06 | .13 | .12 | ... |
| Effect | 1.7 | 4.2 | 5.8 | 6.4 | 4.4 | 7.9 |

| No. of Zone | 7 | 8 | 9 | 10 | 11 |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 10 miles | 15 miles | 20 miles | 25 miles | 30 miles |
| Outer Radius | 15 " | 20 " | 25 " | 30 " | 35 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 2500 | ... | ... | ... | ... | 0.08 |
| 4500 | ... | ... | 0.03 | 0.07 | .12 |
| 5500 | 0.27 | 0.30 | .49 | .49 | .42 |
| 6200 | .50 | .43 | .33 | .35 | .27 |
| 8000 | .20 | .19 | .13 | .09 | .11 |
| 10000 | .03 | .08 | .02 | ... | ... |
| Effect | 6.6 | 4.9 | 1.3 | 0.5 | 0.6 |

Total effect of zones within 35-mile radius = 44.3

Attraction = $44.3 \times 0.00035 = 0.0016$

The regions beyond the 35-mile circle may be divided into six sectors as follows :—

| Sector | Angle | Height <i>feet</i> |
|---------------------------------|-------|-----------------------|
| 1. N. to N. E. | 45 | 5000 |
| 2. N. E. to E. | 45 | 6000 |
| 3. E. to 30° S. of E. | 30 | 2500 |
| 4. 30° S. of E. to 10° E. of S. | 50 | 300 |
| 5. 10° E. of S. to 50° W. of S. | 60 | 6000 |
| 6. 50° W. of S. to N. | 130 | 3500 |

The addition to the orographical correction on account of the outer regions is
0.0006

Hence the total orographical correction is
 $0.0016 + 0.0006 = 0.0022$

In Table XII the results of the season's work are collected and the values of g_0'' and γ_0 computed and compared; γ_0 has, as before, been derived from Helmert's formula of 1884, namely,
 $\gamma_0 = 978.00 (1 + 0.005310 \sin^2 \phi)$
where ϕ is the latitude of the station of observation.

Table XII.—Abstract of Final Results.

| Station | Latitude | Height | Observed g | $g \frac{2h}{R}$ | $g \frac{3}{4} \frac{h}{R}$ | O | Value at sea level g_0'' | γ_0 | $g_0'' - \gamma_0$ |
|-----------------|----------|--------|-----------------|------------------|-----------------------------|--------|----------------------------------|------------|--------------------|
| | ° ' " | feet | | | | | | | |
| Simla ... | 31 6 19 | 7043 | 978.840 | +0.657 | -0.246 | +0.016 | 979.267 | 979.386 | -0.119 |
| Kálka ... | 30 50 8 | 2202 | 979.147 | +0.205 | -0.077 | +0.004 | 979.279 | 979.364 | -0.085 |
| Ludhiána ... | 30 55 25 | 835 | 979.274 | +0.078 | -0.029 | 0.00 | 979.323 | 979.371 | -0.048 |
| Mian Mir ... | 31 31 37 | 708 | 979.383 | +0.066 | -0.025 | 0.00 | 979.424 | 979.420 | +0.004 |
| Ferozepore ... | 30 55 48 | 647 | 979.341 | +0.060 | -0.023 | 0.00 | 979.378 | 979.372 | +0.006 |
| Pathánkot ... | 32 16 33 | 1088 | 979.237 | +0.101 | -0.038 | +0.002 | 979.302 | 979.481 | -0.179 |
| Montgomery ... | 30 39 47 | 557 | 979.321 | +0.052 | -0.019 | 0.00 | 979.354 | 979.351 | +0.003 |
| Dera Gházi Khan | 30 3 49 | 397 | 979.192 | +0.037 | -0.014 | 0.00 | 979.215 | 979.303 | -0.088 |
| Multán ... | 30 11 11 | 404 | 979.243 | +0.038 | -0.014 | 0.00 | 979.267 | 979.312 | -0.045 |
| Jacobabad ... | 28 16 34 | 183 | 979.186 | +0.017 | -0.006 | 0.00 | 979.197 | 979.166 | +0.031 |
| Sibi ... | 29 32 46 | 434 | 979.119 | +0.040 | -0.015 | +0.002 | 979.146 | 979.262 | -0.116 |
| Mach ... | 29 52 25 | 3522 | 978.960 | +0.328 | -0.123 | +0.006 | 979.171 | 979.288 | -0.117 |
| Quetta ... | 30 12 15 | 5520 | 978.851 | +0.515 | -0.193 | +0.002 | 979.175 | 979.314 | -0.139 |

The difference between g at Dehra Dún and g at Mian Mir is by these observations

$$(979.063 - 979.383) = -0.320$$

On p. [120] of Volume V. *Op. G. T. S.* we find Basevi's Vibration Numbers to have been

| | |
|----------------|---|
| At Dehra Dún | 86020.86 |
| At Mian Mir | 86034.55 |
| | |
| Difference = - | 13.69 |
| Now dg = | $\frac{2g}{N} dN$ |
| = | $\frac{2 \times 979.063}{86021} \times 13.69$ |
| = | 0.311 |

Hence the difference between the new result and the old is 0.009, which is not very large. It does not appear therefore that the special stand used by Basevi at Mian Mir and Moré introduced any large error.

CHAPTER V.

The Operations in 1906-07.

The object of the observations undertaken in 1906-07 was the examination in greater detail of the variation in the force of gravity at the foot of the Himalayas and in the neighbourhood of the Siwálik range.

The information on this subject obtained by the work of the former seasons consists of four facts, namely the values of the quantity $(g_0'' - \gamma_0)$ at Pathámkot, Kálka, Dehra Dún and Siliguri.

Pathámkot is situated about 8 miles from the Siwáliks and 16 miles from the Himalayas, but the two ranges are not clearly divided in this locality, the topography being confused and difficult. The value of $(g_0'' - \gamma_0)$ is here -0.179 .

At Kálka which is at the foot of the Himalayas, with the Siwáliks lying 2 miles to the south-west, $g_0'' - \gamma_0 = -0.085$.

At Dehra Dún which lies about half way between the Siwáliks and the Himalayas at a point where they are quite distinct and separated by about 10 miles, $g_0'' - \gamma_0 = -0.126$; and at Siliguri situated about 7 miles from the Himalayas at a place where the Siwáliks are merged in their great neighbour, $g_0'' - \gamma_0 = -0.137$.

Our present information then shows that the deficiency in gravity is by no means constant, but we do not know whether the variations are strictly local in character or whether they are rather to be classed as regional.

The pendulum stations of 1906-07 were chosen with a view to gaining more knowledge of these variations.

The stations selected may be divided into four classes, namely,

- | | | |
|--|-----|---|
| 1. At the foot of the Himalayas, ... | ... | $\left\{ \begin{array}{l} \text{Rájpur} \\ \text{Kálsi} \end{array} \right.$ |
| 2. Midway between the Himalayas and Siwáliks, | ... | Patchpur. |
| 3. In the Siwáliks, ... | ... | $\left\{ \begin{array}{l} \text{Hardwár} \\ \text{Mohan} \\ \text{Asarori} \end{array} \right.$ |
| 4. Outside the Siwáliks but not far from them, | ... | $\left\{ \begin{array}{l} \text{Roorkee} \\ \text{Nojli} \end{array} \right.$ |

Another important object is the location of the position of the line where the excess of the observed over the computed force of gravity attains a maximum.

The existence of such a line, running more or less parallel to the Himalayas, and about 130 miles from them, was deduced from the latitude observations by Colonel Burrard in *Professional Paper No. 5*, and the lines of pendulum observations of 1904-05 and 1905-06 crossed it near Kisnapur, and between Montgomery and Mián Mir, respectively. Three more stations, extending southwards along the Great Arc of Meridian from Nojli, were therefore added to the programme. Kaliána, which was Basevi's Base station, was the most northerly of the three, the others being Meeirut and Gesupur.

The descriptions of the stations are given in the order in which they were visited.

THE STATIONS.

Hardwar.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 29 | 56 | 29 |
| Longitude | ... | ... | 78 | 9 | 19 |
| Height above mean sea level | ... | | | | 949 feet |

The pendulum station was in a small canal bungalow on the right bank of the Ganges Canal about 200 yards below the Mayapur Bridge.

The height was determined by levelling from a bench-mark on the bridge.

Roorkee.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 29 | 52 | 20 |
| Longitude | ... | ... | 77 | 53 | 59 |
| Height above mean sea level | ... | | | | 867 feet |

The pendulum station was in a large room at the N. E. corner of P. W. D. Inspection House, generally called the Malakpur Bungalow.

The height was determined by levelling from nearest bench-mark on the bank of the Ganges Canal.

The room was a very good one with a steady temperature and a thick floor.

Nojli.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 29 | 53 | 28 |
| Longitude | ... | ... | 77 | 40 | 25 |
| Height above mean sea level | ... | | | | 879 feet |

The pendulums were swung in the ground floor room of Nojli Tower Station of the G. T. Survey. The space afforded by the room was scarcely sufficient and the temperature was difficult to control. The height given is that derived from the Principal Triangulation.

Kaliana.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 29 | 30 | 55 |
| Longitude | ... | ... | 77 | 39 | 6 |
| Height above mean sea level | ... | | | | 810 feet |

The pendulums were swung in the east room of the observatory built in 1836 by Major, afterwards Sir George Everest. In this room the Invariable Pendulums were swung by Basevi

in January 1866, in May of the same year, and in April 1870; also by Heaviside in January 1873. The Russian Reversible Pendulums were swung in the same room by Heaviside in February 1873. The observatory is a station of the Principal Triangulation and the height given is that derived from the vertical angles.

As this station is of exceptional importance 5 complete sets of observations were made here.

Meerut.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 29 | 0 | 26 |
| Longitude | ... | ... | 77 | 41 | 40 |
| Height above mean sea level | ... | | | | 734 feet |

The pendulum station was in the south-western room of Bungalow No. 163, which is the last house but one from the western end of the Mall, on the south side.

The height was determined by levelling from a bench-mark of the G. T. Survey on the Church steps.

The observations at Meerut were spread over a period of nearly a month. This was done for reasons unconnected with the pendulum work; it has the effect of rendering the three determinations more independent of each other than is usually the case.

Gesupur.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|----------|
| Latitude | ... | ... | 28 | 33 | 2 |
| Longitude | ... | ... | 77 | 42 | 3 |
| Height above mean sea level | ... | | | | 691 feet |

The pendulums were swung in the north-western room of the bungalow belonging to the Irrigation Department on the left bank of the Ganges Canal near the village of Gesupur.

The height was determined by levelling from a canal bench-mark on the plinth of the milestone marked "120 miles from Maiapur".

Mohan.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 10 | 53 |
| Longitude | ... | ... | 77 | 54 | 37 |
| Height above mean sea level | ... | | | | 1660 feet |

The pendulum station was in the eastern of the two larger rooms of the Forest Rest-house, which stands on a spur of the Siwálik on the western side of the main road from Saháranpur to Rájpur.

The height was determined by levelling from the Mohan Bench-mark of the G. T. Survey. At this and the subsequent stations only two complete sets of observations were made.

Asarori.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 14 | 25 |
| Longitude | ... | ... | 77 | 58 | 3 |
| Height above mean sea level | ... | | | | 2467 feet |

The pendulums were swung in the largest room of the P. W. D. Rest-house which stands on the western side of the Saháranpur-Rájpur road, a little less than 14 miles from Rájpur.

The height was determined by levelling from the Mohobawála Bench-mark of the G. T. Survey. At the close of the second set of swings stars could not be obtained and continuity was carried on to the next night by swinging two pendulums at night and the other two at the corresponding hours next morning.

Dehra Dún was visited and one set of observations made on the way from Asarori to Fatehpur.

Fatehpur.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 25 | 53 |
| Longitude | ... | ... | 77 | 43 | 37 |
| Height above mean sea level | ... | | | | 1434 feet |

The pendulums were swung in the northernmost of the three large rooms of the Military Works Service Inspection Bungalow.

There is a secondary triangulation station on the roof of this bungalow and the co-ordinates given are those of this station, the height being reduced to floor level.

Kalsi.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 31 | 8 |
| Longitude | ... | ... | 77 | 50 | 26 |
| Height above mean sea level | ... | | | | 1684 feet |

The pendulum station was in a bungalow belonging to the Military Works Service, which stands about 150 yards east of the Inspection Bungalow. The latter is commonly called the Kálsi Bungalow, but it should more properly be called the Haripur Bungalow, for the large village of Kálsi is about 2 miles further up the Chakrata road.

The height was determined by levelling from the site of an old station of the triangulation, called 'Gular Ghat'. The station had been washed away by the Jumna some years before but it was possible to identify its position with fair accuracy. The height given above may very possibly be in error by 5 feet, but is not likely to be 10 feet from the truth.

Rajpur.

| | | | ° | ' | " |
|-----------------------------|-----|-----|----|----|-----------|
| Latitude | ... | ... | 30 | 24 | 12 |
| Longitude | ... | ... | 78 | 5 | 47 |
| Height above mean sea level | ... | | | | 3321 feet |

The pendulums were swung in a room lent by the Himalaya Glass Works. The room was one of those on the northern side of the main building which stands about 100 yards south of the public road.

The height was determined by levelling from a bench-mark of the G. T. Survey on the plinth of a house in Rájpur about 250 yards east of the pendulum room.

From Rájpur the pendulums were brought back to Dehra Dún and three complete sets of observations were made with them there.

The set made between the observations at Asarori and Fatehpur has been included with these three in deducing the values of the time of vibration closing.

The results of the determinations of the flexure correction at each station are given in Table I.

Table I. Flexure Correction.

| Station | Date | Observed Correction | Adopted Correction | Station | Date | Observed Correction | Adopted Correction | |
|-------------|-------------------|--|--|--------------|--------------------------------------|--------------------------------------|--|--|
| Dehra Dún | 1906 Nov. 26th | s 47.6×10^{-7} | s $- 47 \times 10^{-7}$ | Gesupur ... | Mar. 3rd | s 42.4×10^{-7} | s $- 42 \times 10^{-7}$ | |
| | 30th | 48.2 46.9 45.6 | | | 6th | 42.5 41.6 42.5 | | |
| Hardwár ... | Dec. 5th | s 64.4×10^{-7} | s $- 64 \times 10^{-7}$ | Mohan ... | Mar. 15th | s 73.7×10^{-7} | s $- 71 \times 10^{-7}$ | |
| | 10th | 65.3 63.9 62.5 63.0 | | | 18th | 72.1 71.9 68.5 70.0 | | |
| | 11th | 63.6 63.1 | | Asarori ... | Mar. 24th | s 49.2×10^{-7} | s $- 50 \times 10^{-7}$ | |
| Roorkee ... | Dec. 15th | s 42.8×10^{-7} | s $- 43 \times 10^{-7}$ | 27th | 50.2 49.1 49.9 | s $- 66 \times 10^{-7}$ | | |
| | 16th | 43.5 42.8 | | Fatehpur ... | Ap. 4th | | s 68.1×10^{-7} | s $- 66 \times 10^{-7}$ |
| 21st | 42.8 41.9 | 7th | 65.4 67.9 64.8 65.3 65.4 65.3 | | Kálsi ... | Ap. 9th | s 69.8×10^{-7} | |
| Nojli ... | Dec. 26th | s 59.6×10^{-7} | s $- 59 \times 10^{-7}$ | Rájpur ... | | 12th | 69.7 70.7 69.0 68.3 68.6 | s $- 55 \times 10^{-7}$ |
| | 29th | 59.2 58.5 58.4 | | | Ap. 16th | s 55.4×10^{-7} | Dehra Dún | |
| Kaliána ... | 1907 Jan. 4th | s 86.2×10^{-7} | s $- 83 \times 10^{-7}$ | 20th | 55.1 55.6 53.4 53.0 | Mar. 29th | | 49.1 49.2 |
| | 6th | 84.2 82.1 82.9 79.8 82.0 | | | Ap. 1st | | 49.1 49.2 | 22nd to 28th s $- 39 \times 10^{-7}$ |
| Meerut ... | Jan. 11th | s 75.9×10^{-7} | s $- 78 \times 10^{-7}$ | 27th | 39.9 39.0 39.7 | 27th | 39.0 39.7 | |
| | 12th | 77.7 79.3 79.9 | | | 28th | | 39.0 39.7 | 27th |
| Meerut ... | Jan. 31st | s 46.2×10^{-7} | s $- 46 \times 10^{-7}$ | 28th | 39.0 39.7 | 28th | 39.0 39.7 | |
| | Feb. 2nd | 47.1 45.5 46.2 | | | 28th | | 39.0 39.7 | 28th |
| Meerut ... | Feb. 18th | s 42.9×10^{-7} | s $- 43 \times 10^{-7}$ | 28th | | 39.0 39.7 | 28th | |
| | 24th | 43.3 43.8 41.9 43.6 | | | 28th | 39.0 39.7 | | 28th |
| Meerut ... | 26th | 41.9 43.6 | s $- 43 \times 10^{-7}$ | 28th | | 39.0 39.7 | 28th | |
| | 26th | 41.9 43.6 | | | 28th | 39.0 39.7 | | 28th |

Table II. Details of the Observations.

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|----------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| Dehra Dun—(Pendulum Room). | | | | | | | | | | | | | | | |
| 26-27 November, 1906. | | | | | | | | | | | | | | | |
| 137 | 2 13 | 34.508 | 9.55 | 20 | 18.67 | +0.01 | 0.866 | 0.5073511 | +561 | -11 | -915 | -514 | -47 | 0.5072585 | |
| 139 | 3 13 | 34.939 | 9.55 | 20 | 18.72 | 0.01 | 0.866 | 0.5072549 | 561 | 11 | 917 | 525 | 47 | 0.5071610 | |
| 138 | 4 14 | 33.427 | 9.55 | 21 | 18.72 | 0.01 | 0.866 | 0.5075925 | 561 | 12 | 917 | 495 | 47 | 0.5075015 | |
| 140 | 5 13 | 35.311 | 9.55 | 20 | 18.71 | 0.01 | 0.866 | 0.5071816 | 561 | 11 | 917 | 525 | 47 | 0.5070877 | |
| | | | | | | | | | | | | Mean | ... | 0.5072522 | |
| 137 | 14 10 | 34.510 | 9.55 | 21 | 18.07 | +0.10 | 0.870 | 0.5073508 | +561 | -12 | -885 | -517 | -47 | 0.5072608 | |
| 139 | 15 15 | 34.974 | 9.55 | 21 | 18.14 | 0.10 | 0.870 | 0.5072516 | 561 | 12 | 889 | 527 | 47 | 0.5071602 | |
| 138 | 16 15 | 33.436 | 9.55 | 22 | 18.25 | 0.10 | 0.868 | 0.5075905 | 561 | 13 | 894 | 496 | 47 | 0.5075016 | |
| 140 | 17 14 | 35.323 | 9.55 | 20 | 18.34 | 0.10 | 0.867 | 0.5071792 | 561 | 11 | 899 | 525 | 47 | 0.5070871 | |
| | | | | | | | | | | | | Mean | ... | 0.5072524 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072523 |
| 27-28 November, 1906. | | | | | | | | | | | | | | | |
| 140 | 2 13 | 35.328 | 9.60 | 23 | 18.53 | +0.04 | 0.867 | 0.5071781 | +564 | -14 | -908 | -525 | -47 | 0.5070851 | |
| 138 | 3 15 | 33.443 | 9.60 | 21 | 18.60 | 0.04 | 0.866 | 0.5075888 | 564 | 12 | 911 | 495 | 47 | 0.5074987 | |
| 139 | 4 14 | 34.971 | 9.60 | 21 | 18.63 | 0.04 | 0.866 | 0.5072525 | 564 | 12 | 913 | 525 | 47 | 0.5071592 | |
| 137 | 5 14 | 34.507 | 9.60 | 19 | 18.64 | 0.04 | 0.866 | 0.5073515 | 564 | 10 | 913 | 514 | 47 | 0.5072595 | |
| | | | | | | | | | | | | Mean | ... | 0.5072506 | |
| 140 | 14 17 | 35.330 | 9.60 | 23 | 18.08 | +0.08 | 0.869 | 0.5071778 | +564 | -14 | -886 | -527 | -47 | 0.5070868 | |
| 138 | 15 18 | 33.444 | 9.60 | 22 | 18.13 | 0.08 | 0.867 | 0.5075886 | 564 | 13 | 888 | 496 | 47 | 0.5075006 | |
| 139 | 16 19 | 34.972 | 9.60 | 24 | 18.21 | 0.08 | 0.866 | 0.5072523 | 564 | 15 | 892 | 525 | 47 | 0.5071608 | |
| 137 | 17 20 | 34.510 | 9.60 | 20 | 18.32 | 0.08 | 0.864 | 0.5073508 | 564 | 11 | 898 | 513 | 47 | 0.5072603 | |
| | | | | | | | | | | | | Mean | ... | 0.5072521 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072514 |
| 28-29 November, 1906. | | | | | | | | | | | | | | | |
| 139 | 2 21 | 34.965 | 9.49 | 27 | 18.52 | 0.00 | 0.863 | 0.5072537 | +557 | -20 | -907 | -523 | -47 | 0.5071597 | |
| 137 | 3 24 | 34.504 | 9.49 | 19 | 18.52 | 0.00 | 0.863 | 0.5073520 | 557 | 10 | 907 | 513 | 47 | 0.5072600 | |
| 140 | 4 27 | 35.318 | 9.49 | 20 | 18.52 | 0.00 | 0.866 | 0.5071803 | 557 | 11 | 907 | 525 | 47 | 0.5070870 | |
| 138 | 5 23 | 33.434 | 9.49 | 23 | 18.52 | 0.00 | 0.864 | 0.5075910 | 557 | 14 | 907 | 494 | 47 | 0.5075005 | |
| | | | | | | | | | | | | Mean | ... | 0.5072518 | |
| 139 | 14 23 | 34.982 | 9.49 | 23 | 18.05 | +0.09 | 0.867 | 0.5072501 | +557 | -14 | -884 | -525 | -47 | 0.5071588 | |
| 137 | 15 25 | 34.510 | 9.49 | 26 | 18.12 | 0.09 | 0.866 | 0.5073507 | 557 | 18 | 888 | 514 | 47 | 0.5072597 | |
| 140 | 16 30 | 35.329 | 9.49 | 20 | 18.21 | 0.09 | 0.866 | 0.5071778 | 557 | 11 | 892 | 525 | 47 | 0.5070860 | |
| 138 | 17 30 | 33.439 | 9.49 | 23 | 18.32 | 0.09 | 0.864 | 0.5075897 | 557 | 14 | 898 | 494 | 47 | 0.5075001 | |
| | | | | | | | | | | | | Mean | ... | 0.5072512 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072515 |
| Hardwar. | | | | | | | | | | | | | | | |
| 7-8 December, 1906. | | | | | | | | | | | | | | | |
| 140 | 21 31 | 34.663 | +16.19 | 19 | 18.12 | -0.08 | 0.904 | 0.5073178 | -950 | -10 | -888 | -548 | -64 | 0.5070718 | |
| 138 | 22 29 | 32.846 | 16.19 | 19 | 18.13 | 0.08 | 0.906 | 0.5077290 | 950 | 10 | 888 | 518 | 64 | 0.5074860 | |
| 139 | 23 28 | 34.328 | 16.19 | 18 | 18.04 | 0.08 | 0.906 | 0.5073903 | 950 | 9 | 884 | 549 | 64 | 0.5071447 | |
| 137 | 0 29 | 33.905 | 16.19 | 17 | 17.91 | 0.08 | 0.906 | 0.5074841 | 950 | 8 | 878 | 538 | 64 | 0.5072403 | |
| | | | | | | | | | | | | Mean | ... | 0.5072357 | |
| 140 | 10 3 | 34.733 | +16.19 | 18 | 15.42 | +0.37 | 0.915 | 0.5073028 | -950 | -9 | -756 | -554 | -64 | 0.5070695 | |
| 138 | 10 54 | 32.898 | 16.19 | 20 | 15.78 | 0.37 | 0.913 | 0.5077165 | 950 | 11 | 773 | 522 | 64 | 0.5074845 | |
| 139 | 11 51 | 34.369 | 16.19 | 20 | 16.14 | 0.37 | 0.912 | 0.5073812 | 950 | 11 | 791 | 553 | 64 | 0.5071443 | |
| 137 | 12 49 | 33.932 | 16.19 | 18 | 16.46 | 0.37 | 0.910 | 0.5074780 | 950 | 9 | 807 | 541 | 64 | 0.5072409 | |
| | | | | | | | | | | | | Mean | ... | 0.5072348 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072353 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | |
|-----------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-------|-------------|-------|----------------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | |
| 8-9 December, 1906. | | | | | | | | | | | | | | | | |
| 137 | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | |
| 137 | 21 20 | 33.902 | +16.40 | 19 | 17.69 | +0.01 | 0.907 | 0.5074846 | -963 | -10 | -867 | -559 | -64 | 0.5072403 | | |
| 139 | 22 20 | 34.327 | 16.40 | 18 | 17.75 | 0.01 | 0.907 | 0.5073906 | 963 | 9 | 870 | 550 | 64 | 0.5071450 | | |
| 138 | 23 22 | 32.849 | 16.40 | 19 | 17.74 | 0.01 | 0.909 | 0.5077282 | 963 | 10 | 869 | 520 | 64 | 0.5074856 | | |
| 140 | 0 22 | 34.671 | 16.40 | 18 | 17.73 | 0.01 | 0.907 | 0.5073162 | 963 | 9 | 869 | 550 | 64 | 0.5070707 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072354 |
| 137 | 9 39 | 33.912 | +16.40 | 13 | 17.30 | +0.16 | 0.910 | 0.5074825 | -963 | -5 | -848 | -541 | -64 | 0.5072404 | | |
| 139 | 10 41 | 34.335 | 16.40 | 19 | 17.51 | 0.16 | 0.909 | 0.5073887 | 963 | 10 | 858 | 551 | 64 | 0.5071441 | | |
| 138 | 11 44 | 32.852 | 16.40 | 19 | 17.66 | 0.16 | 0.907 | 0.5077275 | 963 | 10 | 865 | 519 | 64 | 0.5074854 | | |
| 140 | 12 37 | 34.667 | 16.40 | 19 | 17.78 | 0.16 | 0.906 | 0.5073172 | 963 | 10 | 871 | 549 | 64 | 0.5070715 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072354 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072354 |
| 9-10 December, 1906. | | | | | | | | | | | | | | | | |
| 140 | 21 31 | 34.649 | +16.49 | 20 | 18.46 | -0.06 | 0.908 | 0.5073207 | -968 | -11 | -905 | -550 | -64 | 0.5070709 | | |
| 138 | 22 32 | 32.832 | 16.49 | 20 | 18.50 | 0.06 | 0.906 | 0.5077322 | 968 | 11 | 907 | 518 | 64 | 0.5074854 | | |
| 139 | 23 36 | 34.313 | 16.49 | 18 | 18.42 | 0.06 | 0.907 | 0.5073937 | 968 | 9 | 903 | 550 | 64 | 0.5071443 | | |
| 137 | 0 38 | 33.887 | 16.49 | 18 | 18.27 | 0.06 | 0.907 | 0.5074880 | 968 | 9 | 895 | 539 | 64 | 0.5072405 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072353 |
| 140 | 9 31 | 34.683 | +16.49 | 20 | 17.04 | +0.27 | 0.911 | 0.5073135 | -968 | -11 | -835 | -552 | -64 | 0.5070705 | | |
| 138 | 10 36 | 32.855 | 16.49 | 20 | 17.42 | 0.27 | 0.909 | 0.5077268 | 968 | 11 | 854 | 520 | 64 | 0.5074851 | | |
| 139 | 11 44 | 34.331 | 16.49 | 18 | 17.71 | 0.27 | 0.909 | 0.5073897 | 968 | 9 | 868 | 551 | 64 | 0.5071437 | | |
| 137 | 12 46 | 33.894 | 16.49 | 17 | 17.95 | 0.27 | 0.907 | 0.5074863 | 968 | 8 | 880 | 539 | 64 | 0.5072404 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072349 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072351 |
| Roorkee. | | | | | | | | | | | | | | | | |
| 16-17 December, 1906. | | | | | | | | | | | | | | | | |
| 137 | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | h m s | |
| 137 | 3 27 | 34.249 | +4.90 | 17 | 16.57 | +0.14 | 0.908 | 0.5074076 | -288 | -8 | -812 | -539 | -43 | 0.5072386 | | |
| 139 | 4 28 | 34.683 | 4.90 | 19 | 16.76 | 0.14 | 0.908 | 0.5073135 | 288 | 10 | 821 | 550 | 43 | 0.5071423 | | |
| 138 | 5 29 | 33.173 | 4.90 | 20 | 16.92 | 0.14 | 0.907 | 0.5076515 | 288 | 11 | 829 | 519 | 43 | 0.5074825 | | |
| 140 | 6 30 | 35.022 | 4.90 | 18 | 16.99 | 0.14 | 0.907 | 0.5072418 | 288 | 9 | 833 | 550 | 43 | 0.5070695 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072332 |
| 137 | 15 36 | 34.235 | +4.90 | 19 | 16.75 | +0.08 | 0.912 | 0.5074108 | -288 | -10 | -821 | -542 | -43 | 0.5072404 | | |
| 139 | 16 38 | 34.674 | 4.90 | 20 | 16.86 | 0.08 | 0.912 | 0.5073156 | 288 | 11 | 826 | 553 | 43 | 0.5071435 | | |
| 138 | 17 44 | 33.167 | 4.90 | 19 | 16.93 | 0.08 | 0.911 | 0.5076529 | 288 | 10 | 830 | 521 | 43 | 0.5074837 | | |
| 140 | 18 39 | 35.016 | 4.90 | 18 | 17.00 | 0.08 | 0.908 | 0.5072430 | 288 | 9 | 833 | 550 | 43 | 0.5070707 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072346 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072339 |
| 17-18 December, 1906. | | | | | | | | | | | | | | | | |
| 140 | 3 24 | 35.012 | +5.08 | 20 | 17.11 | +0.01 | 0.911 | 0.5072437 | -298 | -11 | -838 | -552 | -43 | 0.5070695 | | |
| 138 | 4 26 | 33.158 | 5.08 | 19 | 17.13 | 0.01 | 0.910 | 0.5076549 | 298 | 10 | 839 | 521 | 43 | 0.5074838 | | |
| 139 | 5 25 | 34.666 | 5.08 | 19 | 17.13 | 0.01 | 0.910 | 0.5073172 | 298 | 10 | 839 | 551 | 43 | 0.5071431 | | |
| 137 | 6 26 | 34.226 | 5.08 | 18 | 17.13 | 0.01 | 0.910 | 0.5074129 | 298 | 9 | 839 | 541 | 43 | 0.5072399 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072341 |
| 140 | 15 48 | 35.037 | +5.08 | 20 | 16.34 | +0.10 | 0.913 | 0.5072386 | -298 | -11 | -801 | -553 | -43 | 0.5070680 | | |
| 138 | 16 42 | 33.179 | 5.08 | 19 | 16.40 | 0.10 | 0.913 | 0.5076502 | 298 | 10 | 804 | 522 | 43 | 0.5074825 | | |
| 139 | 17 33 | 34.686 | 5.08 | 20 | 16.51 | 0.10 | 0.912 | 0.5073130 | 298 | 11 | 809 | 553 | 43 | 0.5071416 | | |
| 137 | 18 31 | 34.246 | 5.08 | 17 | 16.59 | 0.10 | 0.911 | 0.5074085 | 298 | 8 | 813 | 541 | 43 | 0.5072382 | | |
| | | | | | | | | | | | | | | Mean | ... | 0.5072326 |
| | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072334 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|----------------|---------------------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | |
| 28-29 December, 1906. | | | | | | | | | | | | | | |
| 137 | 4 22 | 34.390 | + 0.25 | 21 | 16.29 | -0.06 | 0.916 | 0.5073768 | - 15 | - 12 | - 798 | - 544 | - 59 | 0.5072340 |
| 139 | 5 24 | 34.835 | 0.25 | 19 | 16.28 | 0.06 | 0.916 | 0.5073812 | 15 | 10 | 798 | 555 | 59 | 0.5071375 |
| 138 | 6 28 | 33.310 | 0.25 | 20 | 16.21 | 0.06 | 0.916 | 0.5076195 | 15 | 11 | 794 | 524 | 59 | 0.5074792 |
| 140 | 7 31 | 35.179 | 0.25 | 18 | 16.13 | 0.06 | 0.916 | 0.5072090 | 15 | 9 | 790 | 555 | 59 | 0.5070662 |
| | | | | | | | | | | | | Mean | ... | 0.5072292 |
| 137 | 16 34 | 34.426 | + 0.25 | 19 | 14.51 | +0.32 | 0.921 | 0.5073688 | - 15 | - 10 | - 711 | - 547 | - 59 | 0.5072346 |
| 139 | 17 26 | 34.860 | 0.25 | 20 | 14.82 | 0.32 | 0.919 | 0.5072760 | 15 | 11 | 726 | 557 | 59 | 0.5071392 |
| 138 | 18 31 | 33.327 | 0.25 | 20 | 15.16 | 0.32 | 0.917 | 0.5076155 | 15 | 11 | 743 | 525 | 59 | 0.5074802 |
| 140 | 19 32 | 35.191 | 0.25 | 19 | 15.48 | 0.32 | 0.916 | 0.5072065 | 15 | 10 | 759 | 555 | 59 | 0.5070667 |
| | | | | | | | | | | | | Mean | ... | 0.5072302 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0.5072297 |
| Kaliana. | | | | | | | | | | | | | | |
| 4-5 January, 1907. | | | | | | | | | | | | | | |
| 137 | 4 55 | 34.270 | + 4.72 | 17 | 16.41 | -0.02 | 0.918 | 0.5074030 | - 277 | - 8 | - 804 | - 545 | - 83 | 0.5072313 |
| 139 | 5 56 | 34.709 | 4.72 | 19 | 16.43 | 0.02 | 0.918 | 0.5073080 | 277 | 10 | 805 | 556 | 83 | 0.5071349 |
| 138 | 6 55 | 33.199 | 4.72 | 20 | 16.40 | 0.02 | 0.918 | 0.5076455 | 277 | 11 | 804 | 525 | 83 | 0.5074755 |
| 140 | 7 56 | 35.054 | 4.72 | 18 | 16.38 | 0.02 | 0.918 | 0.5072350 | 277 | 9 | 803 | 556 | 83 | 0.5070622 |
| | | | | | | | | | | | | Mean | ... | 0.5072260 |
| 137 | 16 50 | 34.272 | + 4.72 | 18 | 15.91 | +0.17 | 0.922 | 0.5074025 | - 277 | - 9 | - 780 | - 548 | - 83 | 0.5072328 |
| 139 | 17 52 | 34.709 | 4.72 | 18 | 16.06 | 0.17 | 0.921 | 0.5073081 | 277 | 9 | 787 | 558 | 83 | 0.5071367 |
| 138 | 18 54 | 33.193 | 4.72 | 20 | 16.24 | 0.17 | 0.918 | 0.5076468 | 277 | 11 | 796 | 525 | 83 | 0.5074776 |
| 140 | 19 53 | 35.045 | 4.72 | 18 | 16.43 | 0.17 | 0.917 | 0.5072371 | 277 | 9 | 805 | 556 | 83 | 0.5070641 |
| | | | | | | | | | | | | Mean | ... | 0.5072278 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0.5072269 |
| 5-6 January, 1907. | | | | | | | | | | | | | | |
| 140 | 4 56 | 35.026 | + 5.39 | 20 | 16.89 | -0.17 | 0.917 | 0.5072410 | - 316 | - 11 | - 828 | - 556 | - 83 | 0.5070616 |
| 138 | 5 58 | 33.172 | 5.39 | 20 | 16.78 | 0.17 | 0.918 | 0.5076518 | 316 | 11 | 822 | 525 | 83 | 0.5074761 |
| 139 | 6 55 | 34.687 | 5.39 | 19 | 16.61 | 0.17 | 0.919 | 0.5073127 | 316 | 10 | 814 | 557 | 83 | 0.5071347 |
| 137 | 7 55 | 34.251 | 5.39 | 17 | 16.44 | 0.17 | 0.918 | 0.5074072 | 316 | 8 | 806 | 545 | 83 | 0.5072314 |
| | | | | | | | | | | | | Mean | ... | 0.5072260 |
| 140 | 17 6 | 35.027 | + 5.39 | 20 | 16.39 | +0.18 | 0.917 | 0.5072407 | - 316 | - 11 | - 803 | - 556 | - 83 | 0.5070638 |
| 138 | 18 5 | 33.168 | 5.39 | 20 | 16.57 | 0.18 | 0.916 | 0.5076529 | 316 | 11 | 812 | 524 | 83 | 0.5074783 |
| 139 | 19 5 | 34.670 | 5.39 | 19 | 16.76 | 0.18 | 0.914 | 0.5073163 | 316 | 10 | 821 | 554 | 83 | 0.5071379 |
| 137 | 20 3 | 34.228 | 5.39 | 18 | 16.92 | 0.18 | 0.913 | 0.5074122 | 316 | 9 | 829 | 542 | 83 | 0.5072343 |
| | | | | | | | | | | | | Mean | ... | 0.5072286 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0.5072273 |
| 8-9 January, 1907. | | | | | | | | | | | | | | |
| 137 | 5 7 | 34.225 | + 5.89 | 18 | 17.16 | +0.03 | 0.911 | 0.5074130 | - 346 | - 9 | - 841 | - 541 | - 78 | 0.5072315 |
| 139 | 6 7 | 34.660 | 5.89 | 18 | 17.19 | 0.03 | 0.911 | 0.5073185 | 346 | 9 | 842 | 552 | 78 | 0.5071358 |
| 138 | 7 7 | 33.149 | 5.89 | 20 | 17.23 | 0.03 | 0.911 | 0.5076571 | 346 | 11 | 844 | 521 | 78 | 0.5074771 |
| 140 | 8 7 | 34.999 | 5.89 | 18 | 17.26 | 0.03 | 0.911 | 0.5072466 | 346 | 9 | 846 | 552 | 78 | 0.5070635 |
| | | | | | | | | | | | | Mean | ... | 0.5072270 |
| 137 | 17 16 | 34.219 | + 5.89 | 18 | 17.33 | +0.05 | 0.912 | 0.5074145 | - 346 | - 9 | - 849 | - 542 | - 78 | 0.5072321 |
| 139 | 18 17 | 34.652 | 5.89 | 18 | 17.40 | 0.05 | 0.912 | 0.5073202 | 346 | 9 | 853 | 553 | 78 | 0.5071363 |
| 138 | 19 19 | 33.142 | 5.89 | 20 | 17.47 | 0.05 | 0.911 | 0.5076589 | 346 | 11 | 856 | 521 | 78 | 0.5074777 |
| 140 | 20 18 | 34.994 | 5.89 | 18 | 17.49 | 0.05 | 0.911 | 0.5072476 | 346 | 9 | 857 | 552 | 78 | 0.5070634 |
| | | | | | | | | | | | | Mean | ... | 0.5072274 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0.5072272 |

Table II. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | | | |
|----------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|-------------|---------------------------|------------------------------------|-----------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | | | |
| 9-10 January, 1907. | | | | | | | | | | | | | | | | | | |
| 140 | 5 8 | 35.046 | + | 5.89 | 20 | 15.34 | +0.13 | 0.918 | 0.5072367 | - | 346 | -11 | -752 | - | 556 | -78 | 0.5070624 | |
| 138 | 6 5 | 33.185 | | 5.89 | 20 | 15.47 | 0.13 | 0.917 | 0.5076488 | | 346 | 11 | 758 | | 525 | 78 | 0.5074770 | |
| 139 | 7 8 | 34.692 | | 5.89 | 18 | 15.60 | 0.13 | 0.913 | 0.5073116 | | 346 | 9 | 764 | | 553 | 78 | 0.5071366 | |
| 137 | 8 9 | 34.249 | | 5.89 | 18 | 15.74 | 0.13 | 0.917 | 0.5074075 | | 346 | 9 | 771 | | 545 | 78 | 0.5072326 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072272 | |
| 140 | 17 23 | 35.015 | + | 5.89 | 20 | 16.63 | +0.10 | 0.917 | 0.5072431 | - | 346 | -11 | -815 | - | 556 | -78 | 0.5070625 | |
| 138 | 18 18 | 33.159 | | 5.89 | 20 | 16.74 | 0.10 | 0.916 | 0.5076549 | | 346 | 11 | 820 | | 524 | 78 | 0.5074770 | |
| 139 | 19 14 | 34.664 | | 5.89 | 18 | 16.83 | 0.10 | 0.916 | 0.5073178 | | 346 | 9 | 825 | | 555 | 78 | 0.5071365 | |
| 137 | 20 11 | 34.224 | | 5.89 | 17 | 16.92 | 0.10 | 0.915 | 0.5074130 | | 346 | 8 | 829 | | 544 | 78 | 0.5072325 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072271 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072272 |
| 10-11 January, 1907. | | | | | | | | | | | | | | | | | | |
| 137 | 5 16 | 34.224 | + | 5.91 | 19 | 16.95 | -0.01 | 0.916 | 0.5074132 | - | 347 | -10 | -831 | - | 544 | -78 | 0.5072322 | |
| 139 | 6 17 | 34.664 | | 5.91 | 18 | 16.94 | 0.01 | 0.916 | 0.5073176 | | 347 | 9 | 830 | | 555 | 78 | 0.5071357 | |
| 138 | 7 21 | 33.155 | | 5.91 | 19 | 16.93 | 0.01 | 0.916 | 0.5076558 | | 347 | 10 | 830 | | 524 | 78 | 0.5074769 | |
| 140 | 8 22 | 35.006 | | 5.91 | 18 | 16.93 | 0.01 | 0.916 | 0.5072451 | | 347 | 9 | 830 | | 555 | 78 | 0.5070632 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072270 | |
| 137 | 17 12 | 34.238 | + | 5.91 | 18 | 16.61 | +0.04 | 0.921 | 0.5074100 | - | 347 | -9 | -814 | - | 547 | -78 | 0.5072305 | |
| 139 | 18 15 | 34.668 | | 5.91 | 19 | 16.70 | 0.04 | 0.918 | 0.5073168 | | 347 | 10 | 818 | | 556 | 78 | 0.5071359 | |
| 138 | 19 19 | 33.158 | | 5.91 | 19 | 16.73 | 0.04 | 0.918 | 0.5076551 | | 347 | 10 | 820 | | 525 | 78 | 0.5074771 | |
| 140 | 20 20 | 35.013 | | 5.91 | 19 | 16.78 | 0.04 | 0.917 | 0.5072435 | | 347 | 10 | 822 | | 556 | 78 | 0.5070622 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072264 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072267 |
| Meerut. | | | | | | | | | | | | | | | | | | |
| 31st January—1st February, 1907. | | | | | | | | | | | | | | | | | | |
| 137 | 3 26 | 34.421 | - | 1.35 | 19 | 17.57 | +0.09 | 0.912 | 0.5073700 | + | 79 | -10 | -861 | - | 542 | -46 | 0.5072320 | |
| 139 | 4 25 | 34.858 | | 1.35 | 19 | 17.65 | 0.09 | 0.911 | 0.5072763 | | 79 | 10 | 865 | | 552 | 46 | 0.5071369 | |
| 138 | 5 28 | 33.333 | | 1.35 | 20 | 17.73 | 0.09 | 0.911 | 0.5076145 | | 79 | 11 | 869 | | 521 | 46 | 0.5074777 | |
| 140 | 6 24 | 35.197 | | 1.35 | 20 | 17.82 | 0.09 | 0.911 | 0.5072052 | | 79 | 11 | 873 | | 552 | 46 | 0.5070649 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072279 | |
| 137 | 15 41 | 34.419 | - | 1.35 | 20 | 17.53 | +0.08 | 0.913 | 0.5073706 | + | 79 | -11 | -859 | - | 542 | -46 | 0.5072327 | |
| 139 | 16 38 | 34.861 | | 1.35 | 19 | 17.57 | 0.08 | 0.913 | 0.5072757 | | 79 | 10 | 861 | | 553 | 46 | 0.5071366 | |
| 138 | 17 31 | 33.334 | | 1.35 | 21 | 17.65 | 0.08 | 0.912 | 0.5076141 | | 79 | 12 | 865 | | 522 | 46 | 0.5074775 | |
| 140 | 18 23 | 35.201 | | 1.35 | 19 | 17.72 | 0.08 | 0.912 | 0.5072046 | | 79 | 10 | 868 | | 553 | 46 | 0.5070648 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072279 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072279 |
| 18-19 February, 1907. | | | | | | | | | | | | | | | | | | |
| 137 | 4 30 | 34.416 | - | 0.91 | 20 | 17.52 | +0.02 | 0.913 | 0.5073711 | + | 53 | -11 | -858 | - | 542 | -43 | 0.5072310 | |
| 139 | 5 29 | 34.851 | | 0.91 | 20 | 17.55 | 0.02 | 0.912 | 0.5072778 | | 53 | 11 | 860 | | 553 | 43 | 0.5071364 | |
| 138 | 6 28 | 33.327 | | 0.91 | 21 | 17.57 | 0.02 | 0.912 | 0.5076157 | | 53 | 12 | 861 | | 522 | 43 | 0.5074772 | |
| 140 | 7 27 | 35.195 | | 0.91 | 19 | 17.59 | 0.02 | 0.912 | 0.5072058 | | 53 | 10 | 862 | | 553 | 43 | 0.5070643 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072272 | |
| 137 | 16 45 | 34.397 | - | 0.91 | 20 | 17.78 | +0.09 | 0.911 | 0.5073752 | + | 53 | -11 | -871 | - | 541 | -43 | 0.5072339 | |
| 139 | 17 34 | 34.836 | | 0.91 | 21 | 17.91 | 0.09 | 0.911 | 0.5072810 | | 53 | 12 | 878 | | 552 | 43 | 0.5071378 | |
| 138 | 18 28 | 33.317 | | 0.91 | 21 | 17.96 | 0.09 | 0.910 | 0.5076180 | | 53 | 12 | 880 | | 521 | 43 | 0.5074777 | |
| 140 | 19 26 | 35.184 | | 0.91 | 20 | 18.08 | 0.09 | 0.909 | 0.5072079 | | 53 | 11 | 886 | | 551 | 43 | 0.5070641 | |
| | | | | | | | | | | | | | | | Mean | ... | 0.5072284 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072278 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|----------------|---------------------------|------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| 24-25 February, 1907. | | | | | | | | | | | | | | | |
| 140 | 4 51 | 35° 150 | + 0° 19 | 21 | 18° 20 | + 0° 03 | 0° 909 | 0° 5072150 | - 11 | - 12 | - 892 | - 551 | - 43 | 0° 5070641 | |
| 138 | 5 49 | 33° 280 | 0° 19 | 21 | 18° 20 | 0° 03 | 0° 910 | 0° 5076266 | 11 | 12 | 896 | 521 | 43 | 0° 5074783 | |
| 139 | 6 46 | 34° 800 | 0° 19 | 21 | 18° 29 | 0° 03 | 0° 910 | 0° 5072886 | 11 | 12 | 896 | 551 | 43 | 0° 5071373 | |
| 137 | 7 46 | 34° 356 | 0° 19 | 18 | 18° 32 | 0° 03 | 0° 909 | 0° 5073843 | 11 | 9 | 898 | 540 | 43 | 0° 5072342 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072285 |
| 140 | 16 3 | 35° 153 | + 0° 19 | 21 | 18° 33 | + 0° 08 | 0° 911 | 0° 5072145 | - 11 | - 12 | - 898 | - 552 | - 43 | 0° 5070629 | |
| 138 | 16 57 | 33° 286 | 0° 19 | 21 | 18° 42 | 0° 08 | 0° 910 | 0° 5076252 | 11 | 12 | 903 | 521 | 43 | 0° 5074762 | |
| 139 | 17 53 | 34° 800 | 0° 19 | 20 | 18° 52 | 0° 08 | 0° 909 | 0° 5072886 | 11 | 11 | 907 | 551 | 43 | 0° 5071363 | |
| 137 | 18 54 | 34° 356 | 0° 19 | 19 | 18° 57 | 0° 08 | 0° 909 | 0° 5073843 | 11 | 10 | 910 | 540 | 43 | 0° 5072329 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072271 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0° 5072278 | |
| Gesupur. | | | | | | | | | | | | | | | |
| 3-4 March, 1907. | | | | | | | | | | | | | | | |
| 137 | 8 36 | 34° 390 | - 3° 09 | 21 | 19° 72 | - 0° 08 | 0° 907 | 0° 5073768 | + 181 | - 12 | - 966 | - 539 | - 42 | 0° 5072390 | |
| 139 | 9 36 | 34° 833 | 3° 09 | 21 | 19° 72 | 0° 08 | 0° 907 | 0° 5072817 | 181 | 12 | 966 | 550 | 42 | 0° 5071428 | |
| 138 | 10 36 | 33° 312 | 3° 09 | 22 | 19° 62 | 0° 08 | 0° 908 | 0° 5076190 | 181 | 13 | 961 | 519 | 42 | 0° 5074836 | |
| 140 | 11 34 | 35° 186 | 3° 09 | 21 | 19° 50 | 0° 08 | 0° 908 | 0° 5072075 | 181 | 12 | 956 | 550 | 42 | 0° 5070696 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072338 |
| 137 | 20 45 | 34° 405 | - 3° 09 | 21 | 18° 72 | + 0° 08 | 0° 912 | 0° 5073735 | + 181 | - 12 | - 917 | - 542 | - 42 | 0° 5072403 | |
| 139 | 21 43 | 34° 848 | 3° 09 | 21 | 18° 72 | 0° 08 | 0° 911 | 0° 5072786 | 181 | 12 | 917 | 552 | 42 | 0° 5071444 | |
| 138 | 22 42 | 33° 323 | 3° 09 | 22 | 18° 83 | 0° 08 | 0° 910 | 0° 5076168 | 181 | 13 | 923 | 521 | 42 | 0° 5074850 | |
| 140 | 23 40 | 35° 191 | 3° 09 | 20 | 18° 92 | 0° 08 | 0° 909 | 0° 5072065 | 181 | 11 | 927 | 551 | 42 | 0° 5070715 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072353 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0° 5072345 | |
| 4-5 March, 1907. | | | | | | | | | | | | | | | |
| 140 | 8 23 | 35° 171 | - 3° 02 | 22 | 19° 54 | - 0° 01 | 0° 907 | 0° 5072107 | + 177 | - 13 | - 957 | - 550 | - 42 | 0° 5070722 | |
| 138 | 9 22 | 33° 305 | 3° 02 | 22 | 19° 53 | 0° 01 | 0° 908 | 0° 5076209 | 177 | 13 | 957 | 519 | 42 | 0° 5074855 | |
| 139 | 10 21 | 34° 834 | 3° 02 | 21 | 19° 52 | 0° 01 | 0° 908 | 0° 5072813 | 177 | 12 | 956 | 550 | 42 | 0° 5071430 | |
| 137 | 11 20 | 34° 385 | 3° 02 | 16 | 19° 52 | 0° 01 | 0° 906 | 0° 5073780 | 177 | 7 | 956 | 538 | 42 | 0° 5072414 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072355 |
| 140 | 20 28 | 35° 197 | - 3° 02 | 20 | 19° 05 | + 0° 08 | 0° 910 | 0° 5072053 | + 177 | - 11 | - 933 | - 551 | - 42 | 0° 5070693 | |
| 138 | 21 26 | 33° 319 | 3° 02 | 22 | 19° 11 | 0° 08 | 0° 909 | 0° 5076175 | 177 | 13 | 936 | 520 | 42 | 0° 5074841 | |
| 139 | 22 24 | 34° 842 | 3° 02 | 21 | 19° 17 | 0° 08 | 0° 909 | 0° 5072798 | 177 | 12 | 939 | 551 | 42 | 0° 5071431 | |
| 137 | 23 24 | 34° 392 | 3° 02 | 19 | 19° 30 | 0° 08 | 0° 908 | 0° 5073765 | 177 | 10 | 946 | 539 | 42 | 0° 5072405 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072343 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0° 5072349 | |
| 5-6 March, 1907. | | | | | | | | | | | | | | | |
| 140 | 8 23 | 35° 168 | - 2° 93 | 22 | 19° 92 | - 0° 10 | 0° 904 | 0° 5072112 | + 172 | - 13 | - 976 | - 548 | - 42 | 0° 5070705 | |
| 138 | 9 23 | 33° 301 | 2° 93 | 22 | 19° 91 | 0° 10 | 0° 906 | 0° 5076216 | 172 | 13 | 976 | 518 | 42 | 0° 5074839 | |
| 139 | 10 22 | 34° 829 | 2° 93 | 20 | 19° 78 | 0° 10 | 0° 906 | 0° 5072825 | 172 | 11 | 969 | 549 | 42 | 0° 5071426 | |
| 137 | 11 22 | 34° 384 | 2° 93 | 20 | 19° 69 | 0° 10 | 0° 907 | 0° 5073781 | 172 | 11 | 965 | 539 | 42 | 0° 5072396 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072342 |
| 140 | 20 20 | 35° 189 | - 2° 93 | 22 | 19° 05 | + 0° 14 | 0° 908 | 0° 5072070 | + 172 | - 13 | - 933 | - 550 | - 42 | 0° 5070704 | |
| 138 | 21 21 | 33° 315 | 2° 93 | 22 | 19° 13 | 0° 14 | 0° 907 | 0° 5076183 | 172 | 13 | 937 | 519 | 42 | 0° 5074844 | |
| 139 | 22 23 | 34° 836 | 2° 93 | 20 | 19° 29 | 0° 14 | 0° 907 | 0° 5072811 | 172 | 11 | 945 | 550 | 42 | 0° 5071435 | |
| 137 | 23 21 | 34° 386 | 2° 93 | 20 | 19° 44 | 0° 14 | 0° 904 | 0° 5073777 | 172 | 11 | 953 | 537 | 42 | 0° 5072406 | |
| | | | | | | | | | | | | | Mean | ... | 0° 5072347 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0° 5072345 | |

Table II. Details of the Observations—(Continued).

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration | |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|------------------------------------|---------------------------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | | Flexure |
| Mohan. | | | | | | | | | | | | | | | |
| 16-17 March, 1907. | | | | | | | | | | | | | | | |
| 137 | 8 47 | 34.403 | - 1.92 | 19 | 16.57 | +0.05 | 0.885 | 0.5073741 | + 113 | - 10 | - 812 | - 526 | - 71 | 0.5072435 | |
| 139 | 9 44 | 34.845 | 1.92 | 20 | 16.62 | 0.05 | 0.885 | 0.5072790 | 113 | 11 | 814 | 536 | 71 | 0.5071471 | |
| 138 | 10 44 | 33.316 | 1.92 | 20 | 16.69 | 0.05 | 0.884 | 0.5076182 | 113 | 11 | 818 | 506 | 71 | 0.5074889 | |
| 140 | 11 43 | 35.188 | 1.92 | 19 | 16.72 | 0.05 | 0.884 | 0.5072071 | 113 | 10 | 819 | 536 | 71 | 0.5070748 | |
| | | | | | | | | | | | | Mean | ... | 0.5072386 | |
| 137 | 20 52 | 34.402 | - 1.92 | 20 | 16.58 | +0.05 | 0.885 | 0.5073741 | + 113 | - 11 | - 812 | - 526 | - 71 | 0.5072434 | |
| 139 | 21 50 | 34.844 | 1.92 | 19 | 16.67 | 0.05 | 0.885 | 0.5072792 | 113 | 10 | 817 | 536 | 71 | 0.5071471 | |
| 138 | 22 50 | 33.316 | 1.92 | 20 | 16.72 | 0.05 | 0.885 | 0.5076182 | 113 | 11 | 819 | 506 | 71 | 0.5074888 | |
| 140 | 23 49 | 35.183 | 1.92 | 19 | 16.73 | 0.05 | 0.884 | 0.5072080 | 113 | 10 | 820 | 536 | 71 | 0.5070756 | |
| | | | | | | | | | | | | Mean | ... | 0.5072387 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072387 |
| 17-18 March, 1907. | | | | | | | | | | | | | | | |
| 140 | 8 47 | 35.183 | - 1.84 | 20 | 16.76 | -0.07 | 0.886 | 0.5072081 | + 108 | - 11 | - 821 | - 537 | - 71 | 0.5070749 | |
| 138 | 9 46 | 33.313 | 1.84 | 20 | 16.73 | 0.07 | 0.887 | 0.5076188 | 108 | 11 | 820 | 507 | 71 | 0.5074887 | |
| 139 | 10 47 | 34.840 | 1.84 | 20 | 16.67 | 0.07 | 0.887 | 0.5072802 | 108 | 11 | 817 | 538 | 71 | 0.5071473 | |
| 137 | 11 47 | 34.396 | 1.84 | 18 | 16.56 | 0.07 | 0.887 | 0.5073756 | 108 | 9 | 811 | 527 | 71 | 0.5072446 | |
| | | | | | | | | | | | | Mean | ... | 0.5072389 | |
| 140 | 20 49 | 35.205 | - 1.84 | 21 | 15.88 | +0.15 | 0.889 | 0.5072036 | + 108 | - 12 | - 778 | - 539 | - 71 | 0.5070744 | |
| 138 | 21 50 | 33.328 | 1.84 | 21 | 16.06 | 0.15 | 0.889 | 0.5076155 | 108 | 12 | 786 | 509 | 71 | 0.5074885 | |
| 139 | 22 49 | 34.848 | 1.84 | 20 | 16.18 | 0.15 | 0.888 | 0.5072786 | 108 | 11 | 793 | 538 | 71 | 0.5071481 | |
| 137 | 23 50 | 34.393 | 1.84 | 18 | 16.33 | 0.15 | 0.888 | 0.5073761 | 108 | 9 | 800 | 527 | 71 | 0.5072462 | |
| | | | | | | | | | | | | Mean | ... | 0.5072393 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072391 |
| Asarori. | | | | | | | | | | | | | | | |
| 24-25 March, 1907. | | | | | | | | | | | | | | | |
| 137 | 9 50 | 34.265 | + 1.99 | 21 | 16.00 | +0.05 | 0.861 | 0.5074042 | - 117 | - 12 | - 784 | - 511 | - 50 | 0.5072568 | |
| 139 | 10 49 | 34.704 | 1.99 | 19 | 16.07 | 0.05 | 0.861 | 0.5073090 | 117 | 10 | 787 | 522 | 50 | 0.5071604 | |
| 138 | 11 48 | 33.193 | 1.99 | 22 | 16.12 | 0.05 | 0.860 | 0.5076468 | 117 | 13 | 790 | 492 | 50 | 0.5075006 | |
| 140 | 12 47 | 35.044 | 1.99 | 22 | 16.14 | 0.05 | 0.860 | 0.5072371 | 117 | 13 | 791 | 521 | 50 | 0.5070879 | |
| | | | | | | | | | | | | Mean | ... | 0.5072514 | |
| 137 | 21 57 | 34.245 | + 1.99 | 21 | 16.73 | 0.00 | 0.860 | 0.5074085 | - 117 | - 12 | - 820 | - 511 | - 50 | 0.5072575 | |
| 139 | 22 56 | 34.686 | 1.99 | 21 | 16.73 | 0.00 | 0.859 | 0.5073129 | 117 | 12 | 820 | 521 | 50 | 0.5071609 | |
| 138 | 23 54 | 33.177 | 1.99 | 22 | 16.73 | 0.00 | 0.860 | 0.5076507 | 117 | 13 | 820 | 492 | 50 | 0.5075015 | |
| 140 | 0 50 | 35.029 | 1.99 | 21 | 16.73 | 0.00 | 0.859 | 0.5072403 | 117 | 12 | 820 | 521 | 50 | 0.5070883 | |
| | | | | | | | | | | | | Mean | ... | 0.5072521 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072517 |
| 25-26 March, 1907. | | | | | | | | | | | | | | | |
| 140 | 9 58 | 35.032 | + 2.05 | 23 | 16.61 | +0.04 | 0.860 | 0.5072396 | - 120 | - 14 | - 814 | - 521 | - 50 | 0.5070877 | |
| 138 | 10 57 | 33.177 | 2.05 | 22 | 16.65 | 0.04 | 0.860 | 0.5076507 | 120 | 13 | 816 | 492 | 50 | 0.5075016 | |
| 139 | 11 54 | 34.689 | 2.05 | 21 | 16.68 | 0.04 | 0.859 | 0.5073123 | 120 | 12 | 817 | 521 | 50 | 0.5071603 | |
| 137 | 12 57 | 34.247 | 2.05 | 19 | 16.71 | 0.04 | 0.857 | 0.5074082 | 120 | 10 | 819 | 509 | 50 | 0.5072574 | |
| | | | | | | | | | | | | Mean | ... | 0.5072518 | |
| 140 | 20 9 | 35.038 | + 2.05 | 22 | 16.50 | +0.10 | 0.860 | 0.5072385 | - 120 | - 13 | - 809 | - 521 | - 50 | 0.5070872 | |
| 138 | 21 8 | 33.181 | 2.05 | 22 | 16.55 | 0.10 | 0.859 | 0.5076498 | 120 | 13 | 811 | 419 | 50 | 0.5075013 | |
| 139 | 22 3 | 34.690 | 2.05 | 22 | 16.68 | 0.10 | 0.859 | 0.5073118 | 120 | 13 | 817 | 521 | 50 | 0.5071597 | |
| 137 | 22 58 | 34.246 | 2.05 | 20 | 16.74 | 0.10 | 0.859 | 0.5074085 | 120 | 11 | 820 | 510 | 50 | 0.5072574 | |
| | | | | | | | | | | | | Mean | ... | 0.5072514 | |
| | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072516 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | | |
|--|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|-------------|---------------------------|-----|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | | |
| 26-27 March, 1907. | | | | | | | | | | | | | | | | | |
| 137 | 9 55 | 34.244 | + | 2.05 | 22 | 16.77 | 0.00 | 0.859 | 0.5074088 | - | 120 | -13 | -822 | Not applied | -510 | -50 | 0.5072573 |
| 139 | 10 52 | 34.685 | | 2.05 | 21 | 16.77 | 0.00 | 0.859 | 0.5073131 | | 120 | 12 | 822 | | -521 | 50 | 0.5071606 |
| 138 | 21 55 | 33.176 | + | 2.05 | 20 | 16.72 | +0.04 | 0.861 | 0.5076509 | - | 120 | -11 | -819 | Not applied | -492 | -50 | 0.5075017 |
| 140 | 22 56 | 35.025 | | 2.05 | 21 | 16.80 | 0.04 | 0.861 | 0.5072411 | | 120 | 12 | 823 | | 522 | 50 | 0.5070884 |
| Time of Vibration of Mean Pendulum ... 0.5072520 | | | | | | | | | | | | | | | | | |
| Mean 25-27 ... 0.5072518 | | | | | | | | | | | | | | | | | |
| General Mean ... 0.5072518 | | | | | | | | | | | | | | | | | |
| Fatehpur. | | | | | | | | | | | | | | | | | |
| 4-5 April, 1907. | | | | | | | | | | | | | | | | | |
| 137 | 10 16 | 34.149 | + | 4.19 | 21 | 22.72 | -0.09 | 0.869 | 0.5074297 | - | 246 | -12 | -1113 | Not applied | -516 | -66 | 0.5072344 |
| 139 | 11 17 | 34.594 | | 4.19 | 21 | 22.60 | 0.09 | 0.870 | 0.5073327 | | 246 | 12 | 1107 | | -527 | 66 | 0.5071369 |
| 138 | 12 18 | 33.091 | | 4.19 | 17 | 22.52 | 0.09 | 0.871 | 0.5076707 | | 246 | 8 | 1103 | | 498 | 66 | 0.5074786 |
| 140 | 13 18 | 34.934 | | 4.19 | 20 | 22.42 | 0.09 | 0.870 | 0.5072603 | | 246 | 11 | 1099 | | 527 | 66 | 0.5070654 |
| Mean ... 0.5072288 | | | | | | | | | | | | | | | | | |
| 137 | 22 16 | 34.160 | + | 4.19 | 21 | 22.31 | +0.11 | 0.870 | 0.5074271 | - | 246 | -12 | -1093 | Not applied | -517 | -66 | 0.5072337 |
| 139 | 23 18 | 34.599 | | 4.19 | 21 | 22.38 | 0.11 | 0.868 | 0.5073315 | | 246 | 12 | 1097 | | 526 | 66 | 0.5071368 |
| 138 | 0 18 | 33.092 | | 4.19 | 22 | 22.51 | 0.11 | 0.868 | 0.5076707 | | 246 | 13 | 1103 | | 496 | 66 | 0.5074783 |
| 140 | 1 17 | 34.931 | | 4.19 | 21 | 22.60 | 0.11 | 0.867 | 0.5072609 | | 246 | 12 | 1107 | | 525 | 66 | 0.5070653 |
| Mean ... 0.5072285 | | | | | | | | | | | | | | | | | |
| Time of Vibration of Mean Pendulum ... 0.5072287 | | | | | | | | | | | | | | | | | |
| 5-6 April, 1907. | | | | | | | | | | | | | | | | | |
| 140 | 10 17 | 34.905 | + | 4.58 | 23 | 23.32 | -0.08 | 0.863 | 0.5072663 | - | 269 | -14 | -1143 | Not applied | -523 | -66 | 0.5070648 |
| 138 | 11 18 | 33.069 | | 4.58 | 20 | 23.22 | 0.08 | 0.864 | 0.5076701 | | 269 | 11 | 1138 | | 494 | 66 | 0.5074783 |
| 139 | 12 17 | 34.572 | | 4.58 | 21 | 23.13 | 0.08 | 0.864 | 0.5073376 | | 269 | 12 | 1133 | | 524 | 66 | 0.5071372 |
| 137 | 13 18 | 34.132 | | 4.58 | 19 | 23.09 | 0.08 | 0.865 | 0.5074335 | | 269 | 10 | 1131 | | 514 | 66 | 0.5072345 |
| Mean ... 0.5072287 | | | | | | | | | | | | | | | | | |
| 140 | 22 22 | 34.911 | + | 4.58 | 22 | 22.90 | +0.13 | 0.865 | 0.5072652 | - | 269 | -13 | -1122 | Not applied | -524 | -66 | 0.5070658 |
| 138 | 23 23 | 33.066 | | 4.58 | 22 | 22.99 | 0.13 | 0.864 | 0.5076765 | | 269 | 13 | 1127 | | 494 | 66 | 0.5074796 |
| 139 | 0 23 | 34.566 | | 4.58 | 21 | 23.13 | 0.13 | 0.864 | 0.5073387 | | 269 | 12 | 1133 | | 524 | 66 | 0.5071383 |
| 137 | 1 25 | 34.121 | | 4.58 | 20 | 23.29 | 0.13 | 0.862 | 0.5074359 | | 269 | 11 | 1141 | | 512 | 66 | 0.5072360 |
| Mean ... 0.5072299 | | | | | | | | | | | | | | | | | |
| Time of Vibration of Mean Pendulum ... 0.5072293 | | | | | | | | | | | | | | | | | |
| Kalsi. | | | | | | | | | | | | | | | | | |
| 9-10 April, 1907. | | | | | | | | | | | | | | | | | |
| 137 | 10 40 | 34.210 | + | 0.07 | 22 | 24.09 | -0.01 | 0.860 | 0.5074162 | - | 4 | -13 | -1180 | Not applied | -511 | -69 | 0.5072385 |
| 139 | 11 38 | 34.656 | | 0.07 | 21 | 24.09 | 0.01 | 0.860 | 0.5073195 | | 4 | 12 | 1180 | | 521 | 69 | 0.5071409 |
| 138 | 12 41 | 33.149 | | 0.07 | 21 | 24.09 | 0.01 | 0.860 | 0.5076571 | | 4 | 12 | 1180 | | 492 | 69 | 0.5074814 |
| 140 | 13 38 | 34.996 | | 0.07 | 21 | 24.06 | 0.01 | 0.860 | 0.5072472 | | 4 | 12 | 1179 | | 521 | 69 | 0.5070687 |
| Mean ... 0.5072324 | | | | | | | | | | | | | | | | | |
| 137 | 22 47 | 34.225 | + | 0.07 | 21 | 23.51 | +0.11 | 0.861 | 0.5074130 | - | 4 | -12 | -1152 | Not applied | -511 | -69 | 0.5072382 |
| 139 | 23 46 | 34.662 | | 0.07 | 22 | 23.62 | 0.11 | 0.861 | 0.5073180 | | 4 | 13 | 1157 | | 522 | 69 | 0.5071415 |
| 138 | 0 46 | 33.152 | | 0.07 | 22 | 23.73 | 0.11 | 0.859 | 0.5076566 | | 4 | 13 | 1163 | | 491 | 69 | 0.5074826 |
| 140 | 1 46 | 34.997 | | 0.07 | 20 | 23.87 | 0.11 | 0.859 | 0.5072470 | | 4 | 11 | 1170 | | 521 | 69 | 0.5070695 |
| Mean ... 0.5072329 | | | | | | | | | | | | | | | | | |
| Time of Vibration of Mean Pendulum ... 0.5072327 | | | | | | | | | | | | | | | | | |

| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | | Reduced Time of Vibration | | | |
|--------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|-----|-------------|-----|----------------|-------------|---------------------------|------------------------------------|-----------|-----------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | Flexure | | | | |
| 10-11 April, 1907. | | | | | | | | | | | | | | | | | | |
| 140 | 10 53 | 34.999 | + | 0.03 | 23 | 23.70 | -0.05 | 0.860 | 0.5072465 | - | 2 | -14 | -1161 | - | 521 | -69 | 0.5070698 | |
| 138 | 11 51 | 33.149 | | 0.03 | 22 | 23.70 | 0.05 | 0.860 | 0.5076571 | | 2 | 13 | 1161 | | 492 | 69 | 0.5074834 | |
| 139 | 12 48 | 34.664 | | 0.03 | 22 | 23.64 | 0.05 | 0.860 | 0.5073178 | | 2 | 13 | 1158 | | 521 | 69 | 0.5071415 | |
| 137 | 13 49 | 34.221 | | 0.03 | 20 | 23.55 | 0.05 | 0.859 | 0.5074138 | | 2 | 11 | 1154 | | 510 | 69 | 0.5072392 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072335 | |
| 140 | 22 58 | 35.025 | + | 0.03 | 20 | 22.92 | +0.14 | 0.865 | 0.5072411 | - | 2 | -11 | -1123 | - | 524 | -69 | 0.5070682 | |
| 138 | 23 60 | 33.167 | | 0.03 | 23 | 23.06 | 0.14 | 0.863 | 0.5076530 | | 2 | 14 | 1130 | | 494 | 69 | 0.5074821 | |
| 139 | 0 54 | 34.671 | | 0.03 | 21 | 23.18 | 0.14 | 0.863 | 0.5073160 | | 2 | 12 | 1136 | | 523 | 69 | 0.5071418 | |
| 137 | 1 55 | 34.222 | | 0.03 | 19 | 23.33 | 0.14 | 0.861 | 0.5074136 | | 2 | 10 | 1143 | | 511 | 69 | 0.5072401 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072330 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072333 |
| Rajpur. | | | | | | | | | | | | | | | | | | |
| 18-19 April, 1907. | | | | | | | | | | | | | | | | | | |
| 137 | 11 32 | 34.332 | - | 5.18 | 23 | 18.92 | +0.08 | 0.825 | 0.5073896 | + | 304 | -14 | -927 | - | 490 | -55 | 0.5072714 | |
| 139 | 12 30 | 34.776 | | 5.18 | 23 | 18.96 | 0.08 | 0.825 | 0.5072937 | | 304 | 14 | 929 | | 500 | 55 | 0.5071743 | |
| 138 | 13 30 | 33.254 | | 5.18 | 24 | 19.07 | 0.08 | 0.823 | 0.5076327 | | 304 | 15 | 934 | | 471 | 55 | 0.5075156 | |
| 140 | 14 29 | 35.114 | | 5.18 | 22 | 19.12 | 0.08 | 0.823 | 0.5072226 | | 304 | 13 | 937 | | 499 | 55 | 0.5071026 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072660 | |
| 137 | 23 30 | 34.325 | - | 5.18 | 23 | 19.10 | +0.18 | 0.824 | 0.5073910 | + | 304 | -14 | -936 | - | 489 | -55 | 0.5072720 | |
| 139 | 0 29 | 34.765 | | 5.18 | 23 | 19.28 | 0.18 | 0.823 | 0.5072960 | | 304 | 14 | 945 | | 499 | 55 | 0.5071751 | |
| 138 | 1 30 | 33.243 | | 5.18 | 23 | 19.45 | 0.18 | 0.823 | 0.5076352 | | 304 | 14 | 953 | | 471 | 55 | 0.5075163 | |
| 140 | 2 30 | 35.099 | | 5.18 | 22 | 19.63 | 0.18 | 0.822 | 0.5072257 | | 304 | 13 | 962 | | 498 | 55 | 0.5071033 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072667 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072663 |
| 19-20 April, 1907. | | | | | | | | | | | | | | | | | | |
| 140 | 11 24 | 35.085 | - | 5.21 | 24 | 20.03 | -0.07 | 0.822 | 0.5072286 | + | 306 | -15 | -981 | - | 498 | -55 | 0.5071043 | |
| 138 | 12 24 | 33.230 | | 5.21 | 23 | 19.94 | 0.07 | 0.823 | 0.5076382 | | 306 | 14 | 977 | | 471 | 55 | 0.5075171 | |
| 139 | 13 21 | 34.749 | | 5.21 | 21 | 19.88 | 0.07 | 0.822 | 0.5072995 | | 306 | 12 | 974 | | 498 | 55 | 0.5071762 | |
| 137 | 14 21 | 34.303 | | 5.21 | 20 | 19.83 | 0.07 | 0.822 | 0.5073958 | | 306 | 11 | 972 | | 488 | 55 | 0.5072738 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072679 | |
| 140 | 23 39 | 35.109 | - | 5.21 | 23 | 19.68 | +0.19 | 0.822 | 0.5072233 | + | 306 | -14 | -964 | - | 498 | -55 | 0.5071008 | |
| 138 | 0 31 | 33.246 | | 5.21 | 22 | 19.80 | 0.19 | 0.822 | 0.5076346 | | 306 | 13 | 970 | | 470 | 55 | 0.5075144 | |
| 139 | 1 26 | 34.759 | | 5.21 | 22 | 19.99 | 0.19 | 0.820 | 0.5072973 | | 306 | 13 | 980 | | 497 | 55 | 0.5071734 | |
| 137 | 2 22 | 34.306 | | 5.21 | 20 | 20.20 | 0.19 | 0.820 | 0.5073951 | | 306 | 11 | 990 | | 487 | 55 | 0.5072714 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072650 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072664 |
| Dehra Dun. | | | | | | | | | | | | | | | | | | |
| 29-30 March 1907. | | | | | | | | | | | | | | | | | | |
| 137 | 10 19 | 34.496 | - | 8.27 | 21 | 18.69 | -0.01 | 0.863 | 0.5073538 | + | 485 | -12 | -916 | - | 513 | -49 | 0.5072533 | |
| 139 | 11 20 | 34.944 | | 8.27 | 17 | 18.70 | 0.01 | 0.863 | 0.5072583 | | 485 | 8 | 916 | | 523 | 49 | 0.5071572 | |
| 138 | 12 20 | 33.410 | | 8.27 | 20 | 18.69 | 0.01 | 0.863 | 0.5075965 | | 485 | 11 | 916 | | 494 | 49 | 0.5074980 | |
| 140 | 13 18 | 35.288 | | 8.27 | 21 | 18.67 | 0.01 | 0.863 | 0.5071862 | | 485 | 12 | 915 | | 523 | 49 | 0.5070848 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072483 | |
| 137 | 23 31 | 34.483 | - | 8.27 | 21 | 18.39 | +0.05 | 0.865 | 0.5073567 | + | 485 | -12 | -901 | - | 514 | -49 | 0.5072576 | |
| 139 | 23 30 | 34.929 | | 8.27 | 21 | 18.47 | 0.05 | 0.863 | 0.5072613 | | 485 | 12 | 905 | | 523 | 49 | 0.5071609 | |
| 138 | 0 24 | 33.395 | | 8.27 | 22 | 18.52 | 0.05 | 0.863 | 0.5075998 | | 485 | 13 | 907 | | 494 | 49 | 0.5075020 | |
| 140 | 1 22 | 35.276 | | 8.27 | 20 | 18.52 | 0.05 | 0.863 | 0.5071888 | | 485 | 11 | 907 | | 523 | 49 | 0.5070883 | |
| | | | | | | | | | | | | | | Not applied | Mean | ... | 0.5072522 | |
| | | | | | | | | | | | | | | | | Time of Vibration of Mean Pendulum | ... | 0.5072503 |

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| Pendulum | Sidereal Time | Coincidence Interval | Clock Rate | Mean Semi-Arc | Temperature | | Density of Air | Observed Time of Vibration | Correction on account of | | | | | Reduced Time of Vibration |
|------------------------------------|---------------|----------------------|------------|---------------|----------------|----------------------|----------------|----------------------------|--------------------------|------|-------------|-------|----------------|---------------------------|
| | | | | | Corrected Mean | Mean change per hour | | | Clock Rate | Arc | Temperature | Lag | Density of Air | |
| 23-24 April 1907. | | | | | | | | | | | | | | |
| 137 | 11 50 | 34'215 | - 2'07 | 19 | 24'00 | - 0'05 | 0'837 | 0'5074151 | + 122 | - 10 | - 1176 | - 497 | - 39 | 0'5072551 |
| 139 | 12 49 | 34'662 | 2'07 | 20 | 24'01 | 0'05 | 0'837 | 0'5073181 | 122 | 11 | 1176 | 507 | 39 | 0'5071570 |
| 138 | 13 49 | 33'154 | 2'07 | 21 | 23'93 | 0'05 | 0'838 | 0'5076560 | 122 | 12 | 1173 | 479 | 39 | 0'5074979 |
| 140 | 14 47 | 35'011 | 2'07 | 20 | 23'88 | 0'05 | 0'838 | 0'5072440 | 122 | 11 | 1170 | 508 | 39 | 0'5070834 |
| | | | | | | | | | | | | Mean | ... | 0'5072484 |
| 137 | 23 57 | 34'213 | - 2'07 | 20 | 23'93 | + 0'12 | 0'838 | 0'5074157 | + 122 | - 11 | - 1173 | - 498 | - 39 | 0'5072558 |
| 139 | 0 56 | 34'653 | 2'07 | 20 | 24'08 | 0'12 | 0'837 | 0'5073202 | 122 | 11 | 1180 | 507 | 39 | 0'5071587 |
| 138 | 1 56 | 33'143 | 2'07 | 21 | 24'17 | 0'12 | 0'836 | 0'5076587 | 122 | 12 | 1184 | 478 | 39 | 0'5074996 |
| 140 | 2 54 | 34'988 | 2'07 | 20 | 24'31 | 0'12 | 0'836 | 0'5072490 | 122 | 11 | 1191 | 507 | 39 | 0'5070864 |
| | | | | | | | | | | | | Mean | ... | 0'5072501 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0'5072493 |
| 24-25 April 1907. | | | | | | | | | | | | | | |
| 140 | 11 55 | 34'972 | - 2'07 | 21 | 24'67 | - 0'13 | 0'836 | 0'5072523 | + 122 | - 12 | - 1209 | - 507 | - 39 | 0'5070878 |
| 138 | 12 55 | 33'132 | 2'07 | 21 | 24'57 | 0'13 | 0'837 | 0'5076612 | 122 | 12 | 1204 | 479 | 39 | 0'5075000 |
| 139 | 13 51 | 34'641 | 2'07 | 20 | 24'43 | 0'13 | 0'839 | 0'5073226 | 122 | 11 | 1197 | 508 | 39 | 0'5071593 |
| 137 | 14 49 | 34'200 | 2'07 | 19 | 24'33 | 0'13 | 0'838 | 0'5074185 | 122 | 10 | 1192 | 498 | 39 | 0'5072568 |
| | | | | | | | | | | | | Mean | ... | 0'5072510 |
| 140 | 23 58 | 34'974 | - 2'07 | 22 | 24'40 | + 0'12 | 0'837 | 0'5072520 | + 122 | - 13 | - 1200 | - 507 | - 39 | 0'5070883 |
| 138 | 0 58 | 33'127 | 2'07 | 21 | 24'55 | 0'12 | 0'837 | 0'5076625 | 122 | 12 | 1203 | 479 | 39 | 0'5075014 |
| 139 | 2 1 | 34'628 | 2'07 | 20 | 24'71 | 0'12 | 0'836 | 0'5073252 | 122 | 11 | 1211 | 507 | 39 | 0'5071606 |
| 137 | 3 2 | 34'185 | 2'07 | 19 | 24'81 | 0'12 | 0'835 | 0'5074217 | 122 | 10 | 1216 | 496 | 39 | 0'5072578 |
| | | | | | | | | | | | | Mean | ... | 0'5072520 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0'5072515 |
| 27-28 April, 1907. | | | | | | | | | | | | | | |
| 137 | 12 2 | 34'156 | - 1'03 | 21 | 25'31 | - 0'02 | 0'834 | 0'5074281 | + 60 | - 12 | - 1240 | - 495 | - 39 | 0'5072555 |
| 139 | 13 0 | 34'594 | 1'03 | 20 | 25'29 | 0'02 | 0'836 | 0'5073328 | 60 | 11 | 1239 | 507 | 39 | 0'5071592 |
| 138 | 14 0 | 33'089 | 1'03 | 21 | 25'27 | 0'02 | 0'836 | 0'5076712 | 60 | 12 | 1238 | 478 | 39 | 0'5075005 |
| 140 | 14 56 | 34'932 | 1'03 | 20 | 25'24 | 0'02 | 0'836 | 0'5072608 | 60 | 11 | 1237 | 507 | 39 | 0'5070874 |
| | | | | | | | | | | | | Mean | ... | 0'5072507 |
| 137 | 0 5 | 34'154 | - 1'03 | 21 | 25'14 | + 0'15 | 0'835 | 0'5074286 | + 60 | - 12 | - 1232 | - 496 | - 39 | 0'5072567 |
| 139 | 1 14 | 34'594 | 1'03 | 22 | 25'33 | 0'15 | 0'835 | 0'5073328 | 60 | 13 | 1241 | 506 | 39 | 0'5071588 |
| 138 | 2 14 | 33'083 | 1'03 | 19 | 25'52 | 0'15 | 0'834 | 0'5076727 | 60 | 10 | 1250 | 477 | 39 | 0'5075011 |
| 140 | 3 11 | 34'930 | 1'03 | 17 | 25'59 | 0'15 | 0'833 | 0'5072611 | 60 | 8 | 1254 | 505 | 39 | 0'5070865 |
| | | | | | | | | | | | | Mean | ... | 0'5072508 |
| Time of Vibration of Mean Pendulum | | | | | | | | | | | | | ... | 0'5072507 |

THE TIME OF VIBRATION AT DEHRA DUN.

The observations at Dehra Dún in November give values of the times of vibration which agree well with those of the previous April, namely :—

| Pendulum | 137 | 138 | 139 | 140 | Mean |
|-------------|-----------|-----------|-----------|-----------|-----------|
| April, 1906 | 0.5072598 | 0.5075001 | 0.5071599 | 0.5070860 | 0.5072515 |
| Nov., 1906 | 0.5072598 | 0.5075005 | 0.5071599 | 0.5070866 | 0.5072517 |

But the observations at Hardwár shewed that a change had taken place in Pendulum No. 137 relatively to the others since the conclusion of the work at Dehra. I have no suggestion to offer as to the cause of this change; the journey is a very short one, the pendulums were packed and handled with the usual care and no accident of any kind is believed to have occurred.

To decide upon the best value of the time of vibration at Dehra Dún it is again necessary to have recourse to the differences between the individual pendulums and the mean pendulum. They are exhibited in Table III, the mean values at each station being given. At the beginning of the table the mean values for the former season, as shewn in Table IV, Chapter IV, are entered for comparison.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

| Station | Date | 137 | v | 138 | v | 139 | v | 140 | v |
|----------------------|------------------------------------|------|-----|--------|-----|-------|-----|--------|-----|
| Mean of all stations | 1905-06 | - 79 | ... | - 2488 | ... | + 912 | ... | + 1655 | ... |
| Dehra Dún | 1906 Nov. 26-29 | 81 | ... | 2488 | ... | 918 | ... | 1651 | ... |
| Hardwár | 1906 Dec. 7-10 | - 52 | + 3 | - 2500 | - 3 | + 909 | - 3 | 1645 | + 6 |
| Roorkee | " 16-21 | 55 | 0 | 2497 | 0 | 912 | 0 | 1640 | 1 |
| Nojli | " 26-29 | 50 | + 5 | 2499 | - 2 | 907 | - 5 | 1641 | 2 |
| Kaliána | 1907 Jan. 4-11 | 51 | 4 | 2500 | 3 | 909 | 3 | 1641 | 2 |
| Meerut | " 31-Feb. 25 | 50 | 5 | 2496 | + 1 | 909 | 3 | 1636 | - 3 |
| Gesupur | March 3- 6 | 56 | - 1 | 2498 | - 1 | 914 | + 2 | 1640 | + 1 |
| Mohan | " 16-18 | 56 | 1 | 2498 | 1 | 915 | 3 | 1640 | 1 |
| Asarori | " 24-27 | 56 | 1 | 2496 | + 1 | 912 | 0 | 1638 | - 1 |
| Fatehpur | April 4- 6 | 57 | 2 | 2496 | 1 | 917 | + 5 | 1637 | 2 |
| Kálsi | " 9-11 | 61 | 6 | 2493 | 4 | 915 | 3 | 1639 | 0 |
| Rájpur | " 18-20 | 58 | 3 | 2494 | 3 | 916 | 4 | 1637 | - 2 |
| Dehra Dún | March 29-30 } April 23-28 } ... | 55 | 0 | 2497 | 0 | 915 | 3 | 1638 | 1 |
| Mean | ... | 55 | ... | 2497 | ... | 912 | ... | 1639 | ... |

It will be seen that after the change in Pendulum No. 137 took place, its length remained tolerably constant. There is some evidence of a tendency to return towards its former state, but the amount of the movement is not large enough to be taken into account.

Accepting the mean of the two values at the top of the table to represent the former relations of the pendulums, and the means of all the values from December to April to represent their new relations, and assuming that Pendulum No. 137 alone changed its length and that it did so by an amount causing a decrement of x in its time of vibration, we have

$$\frac{3x}{4} = (80 - 55); \frac{x}{4} = (2497 - 2488) \text{ or } (915 - 912) \text{ or } (1653 - 1639)$$

Whence $x = 33 \text{ or } 36 \text{ or } 12 \text{ or } 56$

and the mean $x = 34$

It will therefore be necessary to reduce the time of vibration of Pendulum No. 137 at Dehra Dún in November by $34^s \times 10^{-7}$, in order to produce the period which the pendulum would have had if its length had then been the same as it was during the remainder of the season.

Thus the times of vibration at Dehra Dún before and after the season's work become:—

Table IV.—Times of Vibration at Dehra Dún.

| Date | 137 | 138 | 139 | 140 | Mean |
|-------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| November, 1906 | $0^s \cdot 5072564$ | $0^s \cdot 5075005$ | $0^s \cdot 5071599$ | $0^s \cdot 5070866$ | $0^s \cdot 5072508$ |
| March-April, 1907 | $0 \cdot 5072560$ | $0 \cdot 5075002$ | $0 \cdot 5071590$ | $0 \cdot 5070867$ | $0 \cdot 5072505$ |
| Means | $0 \cdot 5072562$ | $0 \cdot 5075004$ | $0 \cdot 5071595$ | $0 \cdot 5070867$ | $0 \cdot 5072507$ |

The value of g at each station has been computed from the differences from the above mean times of vibration at Dehra Dún, employing, as before, the value $979 \cdot 063$ for g at Dehra Dún, and the formula

$$g = g_0 - \frac{2g_0 (s - s_0)}{s_0}$$

Table V.—Mean Times of Vibration and Deduced Values of g .

| Station | | 137 | 138 | 139 | 140 | Mean |
|----------|----|--------------------|--------------------|--------------------|--------------------|--------------------|
| Hardwār | s. | 0.5072405 — 157 | 0.5074853 — 151 | 0.5071444 — 151 | 0.5070708 — 159 | 0.5072353 — 154 |
| | g. | 979.124 | 979.121 | 979.121 | 979.124 | 979.122 |
| Roorkee | s. | 0.5072390 — 172 | 0.5074832 — 172 | 0.5071423 — 172 | 0.5070695 — 172 | 0.5072335 — 172 |
| | g. | 979.129 | 979.129 | 979.129 | 979.129 | 979.129 |
| Nojli | s. | 0.5072349 — 213 | 0.5074798 — 206 | 0.5071392 — 203 | 0.5070658 — 209 | 0.5072299 — 208 |
| | g. | 979.145 | 979.142 | 979.141 | 979.144 | 979.143 |
| Kaliāna | s. | 0.5072321 — 241 | 0.5074770 — 234 | 0.5071361 — 234 | 0.5070629 — 238 | 0.5072270 — 237 |
| | g. | 979.156 | 979.153 | 979.153 | 979.155 | 979.154 |
| Meerut | s. | 0.5072328 — 234 | 0.5074774 — 230 | 0.5071369 — 226 | 0.5070642 — 225 | 0.5072278 — 229 |
| | g. | 979.153 | 979.152 | 979.150 | 979.150 | 979.151 |
| Gesupur | s. | 0.5072402 — 160 | 0.5074844 — 160 | 0.5071432 — 163 | 0.5070706 — 161 | 0.5072346 — 161 |
| | g. | 979.125 | 979.125 | 979.126 | 979.125 | 979.125 |
| Mohan | s. | 0.5072445 — 117 | 0.5074887 — 117 | 0.5071474 — 121 | 0.5070749 — 118 | 0.5072389 — 118 |
| | g. | 979.108 | 979.108 | 979.110 | 979.109 | 979.109 |
| Asarori | s. | 0.5072573 + 11 | 0.5075013 + 9 | 0.5071605 + 10 | 0.5070879 + 12 | 0.5072517 + 10 |
| | g. | 979.059 | 979.060 | 979.059 | 979.058 | 979.059 |
| Fatehpur | s. | 0.5072347 — 215 | 0.5074786 — 218 | 0.5071373 — 222 | 0.5070653 — 214 | 0.5072290 — 217 |
| | g. | 979.146 | 979.147 | 979.149 | 979.146 | 979.147 |
| Kālsi | s. | 0.5072391 — 171 | 0.5074823 — 181 | 0.5071415 — 180 | 0.5070691 — 176 | 0.5072330 — 177 |
| | g. | 979.129 | 979.133 | 979.132 | 979.131 | 979.131 |
| Rājpur | s. | 0.5072722 + 160 | 0.5075158 + 154 | 0.5071748 + 153 | 0.5071027 + 160 | 0.5072664 + 157 |
| | g. | 979.001 | 979.004 | 979.004 | 979.001 | 979.002 |

The Orographical Corrections.

The possible effect of the Siwálik and Himalayan ranges has had to be considered at all the stations of this season, with the exception of Kaliána, Meerut and Gesupur.

It was clear that the effect at Nojli and Roorkee would be small, probably inappreciable, so I examined them first.

Orographical Correction at Nojli.

Height 879 feet.

At Nojli the Siwáliks may be looked upon as occupying a quarter-zone of which the inner radius is 24 miles, the outer 32 miles, and the height 2500 feet. The Himalayas may be considered to consist of a mass 6000 feet high subtending an angle of 125° at the station, and extending from 45 miles to an indefinite distance.

Thus the "effect," using this word in the same way as in Chapter II, of the two ranges is

$$\left\{ \frac{1}{4} \cdot \frac{1600^3}{2} \left(\frac{1}{24} - \frac{1}{32} \right) + \frac{125}{360} \cdot \frac{5100^3}{2} \left(\frac{1}{45} \right) \right\} \times 0.0001894 = 19.6.$$

The orographical correction is therefore

$$19.6 \times 0.000035 = 0.00069$$

Orographical Correction at Roorkee.

Height 867 feet.

Within the 35-mile radius the hills, partly Siwálik and partly Himalayan, may be considered to consist of a wedge-shaped block 3000 feet high, subtending an angle of 36° at the pendulum station, and bounded by circles of 26 and 35 miles radii.

Beyond the 35-mile radius the Himalayas may be equated to a mass 6000 feet high occupying 130° of a zone of which the inner radius is 40 miles and the outer of indefinitely great length.

Thus the effect is

$$\left\{ \frac{36}{360} \times \frac{2100^3}{2} \times \left(\frac{1}{26} - \frac{1}{35} \right) + \frac{130}{360} \times \frac{5100^3}{2} \times \frac{1}{40} \right\} \times 0.0001894 = 22.6.$$

The orographical correction is therefore

$$22.6 \times 0.000035 = 0.00079.$$

The other stations require more careful treatment as considerable inequalities lie within the 35-mile radius in every case. The analysis is shewn in the following tables:—

Table VI.—Orographical Correction at Hardwar.

Height 949 feet.

(The inequalities within 1 mile of the station may be disregarded.)

| No. of Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------------------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|
| Inner radius Outer radius | 1 mile 2 miles | 2 miles 3 " | 3 miles 4 " | 4 miles 5 " | 5 miles 7 " | 7 miles 10 " | 10 miles 15 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 950 | 0.65 | 0.60 | 0.54 | 0.49 | 0.53 | 0.54 | 0.50 |
| 1250 | .27 | .24 | .33 | .31 | .35 | .31 | .23 |
| 1750 | .08 | .14 | .13 | .13 | .07 | .09 | .06 |
| 2250 | | .02 | | .07 | .05 | .06 | .10 |
| 2750 | | | | | | | .06 |
| 3250 | | | | | | | .03 |
| 3750 | | | | | | | .01 |
| 4250 | | | | | | | .01 |
| Effect | 3.6 | 2.3 | 0.9 | 1.1 | 0.9 | 0.8 | 2.5 |

| No. of Zone | 8 | 9 | 10 |
|------------------------------|------------------|------------------|------------------|
| Inner radius Outer radius | 15 miles 20 " | 20 miles 25 " | 25 miles 35 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 950 | 0.48 | 0.48 | 0.47 |
| 1500 | .23 | .13 | .09 |
| 2500 | .05 | .09 | .10 |
| 3000 | .15 | .12 | .14 |
| 5000 | .09 | .18 | .14 |
| 7000 | | | .05 |
| 8500 | | | .01 |
| Effect | 3.7 | 3.5 | 5.8 |

Total effect of zones within 35-mile radius = 25.1

Orographical correction = $25.1 \times .000035 = 0.00088$

The regions lying beyond the 35-mile radius may be classified as follows:—

| Azimuth (from S. by W.) | | | | Mean height <i>feet</i> | |
|----------------------------|----|------|-----|----------------------------|------|
| 0° | to | 130° | ... | ... | 900 |
| 130° | „ | 180° | ... | ... | 5000 |
| 180° | „ | 230° | ... | ... | 7000 |
| 230° | „ | 270° | ... | ... | 5000 |
| 270° | „ | 300° | ... | ... | 3000 |
| 300° | „ | 360° | ... | ... | 900 |

The resulting orographical correction is

$$0.00092$$

Hence the total orographical correction is $0.0009 + 0.0009$
 $= 0.0018$

Mohan.

The immediate surroundings may be taken into account by considering that the station is on the vertex of a cone, the base of which has a radius of $\frac{1}{4}$ mile, and the sides a slope of 1 in 6.

The orographical correction is the difference between the attraction of this cone and that of a cylinder of equal height on the same base.

$$\text{The attraction of the cylinder} = k(h + r - \sqrt{r^2 + h^2})$$

$$\text{The attraction of the cone} = k\left(h - \frac{h^2}{\sqrt{r^2 + h^2}}\right)$$

$$\text{Difference} = kr\left(1 - \frac{r}{\sqrt{r^2 + h^2}}\right)$$

$$\text{Here } h = \frac{r}{6}; r = 1320 \text{ feet}; k = 0.000035$$

$$\begin{aligned} \text{Therefore the difference of attractions} \\ &= 1320(1 - 0.9864) \times 0.000035 \\ &= 0.00063 \end{aligned}$$

*Table VII.—Orographical Correction at Mohan.
Height 1660 feet.*

| No. of Zone | 1 | 2 | No. of Zone | 3 | 4 | 5 | 6 | 7 |
|---------------------|-----------------|-----------------|--------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 1320 feet | 2640 feet | Inner Radius | 1 mile | 2 miles | 3 miles | 5 miles | 7 miles |
| Outer Radius | 2640 „ | 5280 „ | Outer Radius | 2 miles | 3 „ | 5 „ | 7 „ | 10 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1400 | 0.02 | 0.12 | <i>feet</i> 900 | | | 0.22 | 0.33 | 0.37 |
| 1560 | .46 | .40 | 1250 | 0.33 | 0.40 | .16 | .11 | .08 |
| 1800 | .37 | .29 | 1500 | .25 | .09 | .08 | .04 | .22 |
| 2100 | .15 | .19 | 2250 | .23 | .39 | .27 | .33 | .26 |
| | | | 2700 | .19 | .12 | .27 | .19 | .07 |
| Effect | 7.5 | 5.2 | Effect | 16.5 | 5.3 | 6.8 | 2.9 | 1.6 |

Table VII.—Orographical Correction at Mohan—(Continued).

| No. of Zone | 8 | 9 | 10 | 11 |
|------------------------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 10 miles 15 „ | 15 miles 20 „ | 20 miles 25 „ | 25 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 900 | 0.39 | 0.42 | 0.45 | 0.44 |
| 1660 | .32 | .29 | .27 | .13 |
| 2500 | .29 | .06 | | |
| 3000 | | .17 | .09 | .13 |
| 5000 | | .05 | .11 | .16 |
| 7000 | | .01 | .08 | .12 |
| 9000 | | | | .02 |
| Effect | 1.3 | 2.3 | 3.7 | 7.1 |

Total effect of zones within 35-mile radius = 60.2

Orographical correction = $60.2 \times 0.000035 = 0.00211$

The masses lying beyond the 35-mile radius may be classified as follows :—

| Azimuth (From S. by W.) | | | | Mean Height |
|----------------------------|----|-----|-----|-------------|
| | | | | <i>feet</i> |
| 0 | to | 130 | ... | 900 |
| 130 | „ | 190 | ... | 5000 |
| 190 | „ | 250 | ... | 7000 |
| 250 | „ | 280 | ... | 5000 |
| 280 | „ | 305 | ... | 3000 |
| 305 | „ | 360 | ... | 900 |

The resulting orographical correction is

0.00075

Hence the total orographical correction is

$$0.00063 + 0.00211 + 0.00075 \\ = 0.00349$$

Table VIII.—Orographical Correction at Asarori.

Height 2467 feet.

| No. of Zone | 1 | 2 | 3 | 4 | 5 |
|------------------------------|--------------------|---------------------|---------------------|---------------------------|-------------------|
| Inner Radius Outer Radius | 500 feet 1000 „ | 1000 feet 1700 „ | 1700 feet 2640 „ | $\frac{1}{2}$ mile 1 „ | 1 mile 2 miles |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1950 | | | | | 0.14 |
| 2250 | | | | 0.30 | .26 |
| 2350 | 0.10 | 0.06 | 0.07 | | |
| 2450 | .41 | .28 | .21 | .43 | .33 |
| 2550 | .41 | .40 | .40 | | |
| 2650 | .08 | .20 | .26 | .18 | .19 |
| 2750 | | .06 | .06 | | |
| 2850 | | | | .09 | .08 |
| Effect | 4.1 | 3.4 | 2.0 | 3.3 | 3.1 |

| No. of Zone | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|------------------------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 2 miles 3 „ | 3 miles 5 „ | 5 miles 7 „ | 7 miles 10 „ | 10 miles 15 „ | 15 miles 20 „ | 20 miles 25 „ | 25 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 900 | | | | 0.07 | 0.24 | 0.31 | 0.38 | 0.45 |
| 1250 | | | 0.06 | .12 | | | | |
| 1500 | | | | | .29 | .30 | .22 | .12 |
| 1750 | | 0.27 | .26 | .37 | | | | |
| 2250 | 0.77 | .56 | .54 | .36 | .12 | .06 | | |
| 2700 | .23 | .17 | .14 | .08 | .06 | .03 | | |
| 3250 | | | | | .17 | .04 | .07 | .09 |
| 5000 | | | | | .10 | .12 | .15 | .20 |
| 7000 | | | | | .02 | .12 | .15 | .12 |
| 8500 | | | | | | .02 | .03 | .02 |
| Effect | 0.9 | 6.0 | 1.0 | 1.1 | 6.4 | 8.1 | 5.9 | 6.0 |

Total effect of zones within 35-mile radius = 51.3

Orographical correction = $51.3 \times 0.000035 = 0.0018$

The outer regions may be divided up in the same way as in the case of Mohan, but the height of the station being greater by 800 feet the resulting correction is slightly different; its value is

$$0.0006$$

Hence total orographical correction is $0.0018 + 0.0006$
 $= 0.0024.$

Table IX.—Orographical Correction at Fatehpur.

Height 1434 feet.

(Up to 3 miles from the station the inequalities are not large enough to be taken into account.)

| No. of Zone | 1 | 2 | 3 | No. of Zone | 4 | 5 | 6 | 7 |
|---------------------|-----------------|-----------------|-----------------|--------------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 3 miles | 5 miles | 7 miles | Inner Radius | 10 miles | 15 miles | 20 miles | 25 miles |
| Outer Radius | 5 " | 7 " | 10 " | Outer Radius | 15 " | 20 " | 25 " | 35 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1300 | 0.14 | 0.07 | 0.17 | <i>feet</i> 900 | 0.07 | 0.24 | 0.33 | 0.32 |
| 1700 | .65 | .65 | .36 | 1600 | .34 | .13 | .10 | .15 |
| 2250 | .13 | .15 | .16 | 2500 | .11 | .09 | .04 | .02 |
| 2500 | | .03 | .14 | 3000 | .25 | .17 | .14 | .09 |
| 2700 | .08 | .10 | .08 | 5000 | .15 | .16 | .17 | .09 |
| 3500 | | | .05 | 7000 | .08 | .19 | .16 | .23 |
| 4500 | | | .03 | 9000 | | .02 | .06 | .10 |
| 5500 | | | .01 | | | | | |
| Effect | 3.6 | 1.8 | 4.6 | Effect | 16.0 | 15.8 | 10.6 | 15.1 |

Total effect of zones within 35-mile radius = 67.5

Orographical correction = $67.5 \times 0.00035 = 0.0024$

The outer regions may be estimated as follows:—

Azimuth

(From S. by W.)

| | | | |
|------------|-----|-----|------------------------------|
| 0° to 120° | ... | ... | Height <i>feet</i> 900 |
| 120 " 200 | ... | ... | 5000 |
| 200 " 260 | ... | ... | 7000 |
| 260 " 315 | ... | ... | 4000 |
| 315 " 360 | ... | ... | 900 |

The resulting orographical correction is

$$0.0009$$

Hence total orographical correction is $0.0024 + 0.0009$
 $= 0.0033$

Kalsi.

The station is situated about 30 yards from the outer edge of a shelf of land below which flows the Jumna and above which stands the outer range of the Himalayas.

An approximation to the masses within a radius of $\frac{1}{4}$ mile may be made by assuming that the station is 100 feet from the edge of a cliff 100 feet high, and that if circles be described with radii of 100 feet and $\frac{1}{4}$ mile respectively, half the land enclosed between them will be at the same level as the station and half 100 feet below it.

The orographical correction on account of this half zone is
0.00065

From $\frac{1}{4}$ mile to 35 miles the analysis has been made in the usual way.

Table X.—Orographical Correction at Kalsi.

Height 1684 feet.

| No. of Zone | 1 | No. of Zone | 2 | 3 | 4 | 5 |
|------------------------------|---------------------------|------------------------------|-------------------|-----------------|-----------------|-----------------|
| Inner Radius Outer Radius | $\frac{1}{4}$ mile 1 " | Inner Radius Outer Radius | 1 mile 3 miles | 3 miles 5 " | 5 miles 7 " | 7 miles 10 " |
| Height | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1584 | 0.67 | <i>feet</i> 1550 | 0.27 | 0.22 | 0.24 | 0.26 |
| 1840 | .17 | 1850 | .23 | .09 | .10 | .07 |
| 2500 | .16 | 2500 | .34 | .26 | .15 | .13 |
| | | 3500 | .10 | .21 | .15 | .12 |
| | | 4500 | .06 | .16 | .17 | .18 |
| | | 5550 | | .05 | .14 | .13 |
| | | 6500 | | .01 | .05 | .10 |
| | | 7200 | | | | .01 |
| Effect | 29.1 | Effect | 64.6 | 38.5 | 27.5 | 26.0 |

Table X.—Orographical Correction at Kalsi—(Continued).

| No. of Zone | 6 | 7 | 8 | 9 |
|------------------------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 10 miles 15 " | 15 miles 20 " | 20 miles 25 " | 25 miles 35 " |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 900 | | 0.02 | 0.17 | 0.30 |
| 1400 | 0.26 | .27 | .12 | .12 |
| 2500 | .11 | .14 | .08 | .02 |
| 3000 | .19 | .15 | .14 | .08 |
| 5000 | .26 | .12 | .17 | .16 |
| 7000 | .17 | .21 | .24 | .21 |
| 9000 | .01 | .09 | .08 | .10 |
| 10500 | | | | .01 |
| Effect | 26.7 | 19.9 | 12.6 | 14.7 |

Total effect of zones within 35-mile radius ... = 259.6

Orographical correction = $259.6 \times 0.00035 = 0.00909$.

The regions outside the 35-mile radius may be classified as follows:—

| Azimuth (From S. by W.) | | | Height | |
|----------------------------|----|---------|-------------|------|
| | | | <i>feet</i> | |
| 0 | to | 125 ... | ... | 900 |
| 125 | " | 195 ... | ... | 5000 |
| 195 | " | 255 ... | ... | 7000 |
| 255 | " | 295 ... | ... | 5000 |
| 295 | " | 340 ... | ... | 3000 |
| 340 | " | 360 ... | ... | 900 |

The resulting orographical correction is 0.00081

Hence the total orographical correction is $0.00065 + 0.00909 + 0.00081$
 $= 0.01055$

Table XI.—Orographical Correction at Rájpur.
Height 3321 feet.

(Up to a radius of 500 feet the inequalities may be disregarded).

| No. of Zone | 1 | 2 | 3 | No. of Zone | 4 | 5 | No. of Zone | 6 | 7 |
|------------------------------|--------------------|---------------------|---------------------|------------------------------|---------------------------|-------------------|------------------------------|-----------------|-----------------|
| Inner Radius Outer Radius | 500 feet 1000 „ | 1000 feet 1700 „ | 1700 feet 2640 „ | Inner Radius Outer Radius | $\frac{1}{2}$ mile 1 „ | 1 mile 2 miles | Inner Radius Outer Radius | 2 miles 3 „ | 3 miles 5 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 3050 | | 0.02 | 0.15 | <i>feet</i> 2800 | 0.15 | 0.30 | <i>feet</i> 2300 | 0.07 | 0.17 |
| 3150 | 0.01 | .12 | .31 | 3150 | .43 | .20 | 2900 | .37 | .24 |
| 3250 | .25 | .51 | .26 | 3600 | .33 | .11 | 3700 | .17 | .11 |
| 3350 | .70 | .35 | .11 | 4500 | .09 | .21 | 4500 | .20 | .09 |
| 3450 | .04 | | .05 | 5500 | | .17 | 5500 | .14 | .16 |
| 3550 | | | .06 | 6500 | | .01 | 6500 | .05 | .20 |
| 3650 | | | .06 | | | | 7200 | | .03 |
| Effect | 2.0 | 1.5 | 3.5 | Effect | 18.2 | 61.6 | Effect | 25.8 | 45.8 |

| No. of Zone | 8 | 9 | 10 | 11 | 12 | 13 |
|------------------------------|-----------------|-----------------|------------------|------------------|------------------|------------------|
| Inner Radius Outer Radius | 5 miles 7 „ | 7 miles 10 „ | 10 miles 15 „ | 15 miles 20 „ | 20 miles 25 „ | 25 miles 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 900 | | | | | 0.06 | 0.22 |
| 1500 | | | 0.20 | 0.24 | .24 | .14 |
| 2500 | 0.43 | 0.40 | | | | |
| 3000 | | | .27 | .23 | .22 | .12 |
| 5000 | .28 | .29 | .21 | .33 | .23 | .21 |
| 7000 | .27 | .25 | .23 | .20 | .21 | .19 |
| 8500 | .02 | .06 | | | | |
| 9000 | | | .09 | | .04 | .11 |
| 10500 | | | | | | .01 |
| Effect | 28.7 | 25.0 | 22.8 | 7.2 | 5.7 | 9.4 |

Total effect of zones within 35-mile radius = 257.2
 Orographical correction = 257.2×0.000035
 = 0.00900.

The outer regions may be classified thus :—

| Azimuth (From S. by W.) | | | Height feet | | |
|----------------------------|----|---------|----------------|-----|------|
| 0 | to | 120 ... | ... | ... | 900 |
| 120 | „ | 180 ... | ... | ... | 5000 |
| 180 | „ | 250 ... | ... | ... | 9000 |
| 250 | „ | 290 ... | ... | ... | 4000 |
| 290 | „ | 320 ... | ... | ... | 3000 |
| 320 | „ | 360 ... | ... | ... | 900 |

The resulting orographical correction is 0.00088

Hence the total orographical correction is $0.00900 + 0.00088$
 $= 0.00988$

Dehra Dún.

The maps of the Dún having all been contoured the opportunity of recomputing the orographical correction for Dehra Dún was favourable, and this has therefore been done. The value which has been used in Chapter II depends, up to a radius of 30 miles, on the calculation made in Vol. V. *Op. G. T. S.* p. [177], though for the outer regions I substituted my own figures. It is desirable that the orographical correction of all the stations in and about the Dún be based on the same estimates of height, so that they may be at least consistent, and, as there was so large a divergence between my heights and those of Vol. V in the outer zones, it seemed probable that there might be some discrepancy in the inner ones also.

Table XII.—Orographical Correction at Dehra Dún.

Height 2241 feet.

(Up to a radius of 3 miles the inequalities may be disregarded).

| No. of Zone | 1 | 2 | 3 | No. of Zone | 4 | 5 | 6 | 7 |
|---------------------|-----------------|-----------------|-----------------|--------------------|-----------------|-----------------|-----------------|-----------------|
| Inner Radius | 3 miles | 5 miles | 7 miles | Inner Radius | 10 miles | 15 miles | 20 miles | 25 miles |
| Outer Radius | 5 „ | 7 „ | 10 „ | Outer Radius | 15 „ | 20 „ | 25 „ | 35 „ |
| Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | Height | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> | <i>Fraction</i> |
| <i>feet</i> 1800 | 0.20 | 0.26 | 0.27 | <i>feet</i> 900 | | 0.12 | 0.23 | 0.31 |
| 2100 | .37 | .18 | .10 | 1500 | 0.29 | .32 | .21 | .14 |
| 2350 | .16 | .10 | .11 | 2500 | .20 | .10 | .05 | |
| 2900 | .24 | .21 | .11 | 3000 | .13 | .06 | .09 | .13 |
| 3600 | .03 | .19 | .11 | 5000 | .18 | .17 | .27 | .17 |
| 4500 | | .06 | .11 | 7000 | .17 | .18 | .13 | .18 |
| 5500 | | .00 | .10 | 8500 | .03 | .05 | .02 | .07 |
| 6500 | | | .08 | | | | | |
| 7200 | | | .01 | | | | | |
| Effect | 2.7 | 4.5 | 15.1 | Effect | 21.1 | 12.7 | 6.1 | 9.3 |

Total effect of zones within 35-mile radius = 71.5

Orographical correction = 71.5×0.00035

= 0.00250

The regions outside the 35-mile radius may be analysed in the same way as in Chapter II. There the inner radius was 30 miles, here it is 35 miles, the value of the correction there obtained must consequently be multiplied by $\frac{30}{35}$. It becomes therefore

$$0.00111$$

Hence the total orographical correction is

$$0.0036$$

The value adopted in Chapter II was

$$0.0041$$

The two values thus agree satisfactorily.

Table XIII.—Abstract of Final Results.

| Station | Latitude | Height | Observed g | $g \frac{2h}{R}$ | $g \frac{3}{4} \frac{h}{R}$ | O | Value at sea level g_0 | γ_0 | $g_0'' - \gamma_0$ |
|--------------|----------------|----------|-----------------|------------------|-----------------------------|--------|--------------------------------|------------|--------------------|
| Hardwár ... | ° ' " 29 56 29 | feet 949 | 979.122 | +0.089 | -0.033 | +0.002 | 979.180 | 979.294 | -0.114 |
| Roorkee ... | 29 52 20 | 867 | 979.129 | +0.081 | -0.030 | +0.001 | 979.181 | 979.288 | -0.107 |
| Nojli ... | 29 53 28 | 879 | 979.143 | +0.082 | -0.031 | +0.001 | 979.195 | 979.290 | -0.095 |
| Kaliána ... | 29 30 55 | 810 | 979.154 | +0.076 | -0.028 | 0.00 | 979.202 | 979.260 | -0.058 |
| Meerut ... | 29 0 26 | 734 | 979.151 | +0.069 | -0.026 | 0.00 | 979.194 | 979.221 | -0.027 |
| Gesupur ... | 28 33 2 | 691 | 979.125 | +0.065 | -0.024 | 0.00 | 979.166 | 979.186 | -0.020 |
| Mohan ... | 30 10 53 | 1660 | 979.109 | +0.155 | -0.058 | +0.003 | 979.209 | 979.313 | -0.104 |
| Asarori | 30 14 25 | 2467 | 979.059 | +0.231 | -0.087 | +0.002 | 979.205 | 979.317 | -0.112 |
| Fatehpur ... | 30 25 53 | 1434 | 979.147 | +0.132 | -0.049 | +0.003 | 979.233 | 979.333 | -0.100 |
| Kálsi ... | 30 31 8 | 1684 | 979.131 | +0.158 | -0.059 | +0.011 | 979.241 | 979.339 | -0.098 |
| Rájpur ... | 30 24 12 | 3321 | 979.002 | +0.311 | -0.117 | +0.010 | 979.206 | 979.330 | -0.124 |

CHAPTER VI.

The Accuracy of the observations.

There are two convenient ways of determining the probable error of the reduced time of vibration of a pendulum. These have already been mentioned in Chapter I.

I may here repeat that if ρ be the probable error of one complete determination of the time of vibration of any pendulum, that is to say, of the result of a night and a day observation preceded and followed by time determinations; and if for any series of observations the differences between the individual pendulums and the mean pendulum, the mean differences, and the residuals be formed as in Table III of Chapter III; and if all the residuals of the series be squared and summed, then

$$\rho = 0.6745 \sqrt{\frac{[v v]}{3(n-1)}}$$

where n is the number of sets of observations.

Also since there are four pendulums, the probable error of one determination of the time of vibration of the mean pendulum is

$$\rho_o = \frac{\rho}{2}$$

Secondly if there are two or more sets of observations at each station, and if the differences between the several values of the time of vibration of the mean pendulum and the station-means be called v' , then, if there are n stations and m sets of observations in all, the probable error of one determination of the time of vibration of the mean pendulum is

$$\mu_o = 0.6745 \sqrt{\frac{[v' v']}{m-n}}$$

It will be seen that the same words are used to define ρ_o and μ_o but they are not identical quantities: I shall call the two ways of computing the above probable error A and B respectively and the results ρ_o and μ_o

In Chapter II the quantities necessary for computing ρ_o were not given, they are shewn in the following table:—

Table I.—Differences between Individual Pendulums and Mean Pendulum.

| Station | Date | 137 | v | 138 | v | 139 | v | 140 | v |
|--------------------------------------|------------|-----|-----|------|-----|-----|-----|------|-----|
| Dehra Dún ... | 1904 | | | | | | | | |
| | Jan. 25-26 | 72 | 4 | 2485 | 10 | 898 | 7 | 1658 | 1 |
| | " 26-27 | 76 | 8 | 2484 | 11 | 895 | 10 | 1663 | 6 |
| | " 29-30 | 73 | 5 | 2493 | 2 | 903 | 2 | 1663 | 6 |
| | Feb. 3-4 | 69 | 1 | 2491 | 4 | 903 | 2 | 1656 | 1 |
| | " 4-5 | 74 | 6 | 2491 | 4 | 904 | 1 | 1660 | 3 |
| Madras ... | " 5-6 | 68 | 0 | 2489 | 6 | 903 | 2 | 1652 | 5 |
| | Mar. 3-4 | 41 | 27 | 2508 | 13 | 905 | 0 | 1645 | 12 |
| | " 4-5 | 80 | 12 | 2483 | 12 | 907 | 2 | 1656 | 1 |
| | " 6-7 | 45 | 23 | 2507 | 12 | 913 | 8 | 1637 | 20 |
| Colaba ... | " 7-8 | 62 | 6 | 2493 | 2 | 911 | 6 | 1644 | 13 |
| | Mar. 16-17 | 68 | 0 | 2495 | 0 | 903 | 2 | 1661 | 4 |
| | " 17-18 | 74 | 6 | 2496 | 1 | 904 | 1 | 1666 | 9 |
| | " 20-21 | 64 | 4 | 2505 | 10 | 905 | 0 | 1664 | 7 |
| Mussooree (<i>Dunseverick</i>) ... | " 21-22 | 72 | 4 | 2500 | 5 | 912 | 7 | 1660 | 3 |
| | Ap. 22-23 | 64 | 4 | 2501 | 6 | 909 | 4 | 1653 | 4 |
| | " 23-24 | 70 | 2 | 2497 | 2 | 905 | 0 | 1661 | 4 |
| | " 25-26 | 66 | 2 | 2496 | 1 | 907 | 2 | 1654 | 3 |
| Mussooree (<i>Camel's Back</i>) | " 26-27 | 68 | 0 | 2495 | 0 | 909 | 4 | 1653 | 4 |
| | May 16-17 | 69 | 1 | 2495 | 0 | 897 | 8 | 1665 | 8 |
| | " 17-18 | 81 | 13 | 2500 | 5 | 919 | 14 | 1663 | 6 |
| | " 18-19 | 50 | 18 | 2498 | 3 | 896 | 9 | 1650 | 7 |
| Dehra Dún | May 27-28 | 76 | 8 | 2490 | 5 | 909 | 4 | 1656 | 1 |
| | " 28-29 | 84 | 16 | 2491 | 4 | 904 | 1 | 1670 | 13 |
| | June 2-3 | 58 | 10 | 2504 | 9 | 906 | 1 | 1656 | 1 |
| | " 3-4 | 68 | 0 | 2494 | 1 | 901 | 4 | 1660 | 3 |
| | " 4-5 | 73 | 5 | 2497 | 2 | 909 | 4 | 1660 | 3 |
| Mean ... | ... | 68 | ... | 2495 | ... | 905 | ... | 1657 | ... |

The sums of the squares of the residuals are for the different pendulums :—

| | | | | |
|----------|------|------|-----|------|
| Pendulum | 137 | 138 | 139 | 140 |
| [v v] | 2611 | 1082 | 747 | 1372 |

The number of sets is 26.

$$\text{Hence } \rho = 0.6745 \sqrt{\frac{5812}{3(25)}}$$

$$= \pm 5.9$$

$$\text{and } \rho_0 = \pm 3.0$$

Employing method B we have

Table II.

| Station | No. of Sets | v' v' |
|---------------------------------------|-------------|-------|
| Dehra Dún ... | 6 | 47 |
| Madras ... | 4 | 117 |
| Colaba ... | 4 | 167 |
| Mussooree (<i>Dunseverick</i>) ... | 4 | 78 |
| Mussooree (<i>Camel's Back</i>) ... | 3 | 233 |
| Dehra Dún ... | 5 | 315 |
| Total ... | 26 | 957 |

The number of stations is 6.

Hence

$$\begin{aligned}\mu_0 &= 0.6745 \sqrt{\frac{957}{26-6}} \\ &= \pm 4.7.\end{aligned}$$

The number of stations is small and it would be rash to generalise from the values of ρ_0 and μ_0 derived from them. I therefore go on to examine the results of the next season's work.

The Season 1904-05.

In Table III of Chapter III the quantities necessary for computing ρ_0 are given.

There are 48 sets of observations and the following values of $[vv]$ are found by squaring and summing the quantities v .

| | | | | |
|----------|------|------|------|------|
| Pendulum | 137 | 138 | 139 | 140 |
| $[vv]$ | 1277 | 2037 | 3812 | 4820 |

Hence

$$\begin{aligned}\rho &= 0.6745 \sqrt{\frac{11946}{3 \times 47}} \\ &= \pm 6.1\end{aligned}$$

and

$$\rho_0 = \pm 3.1$$

In the computation of μ_0 by method B we have the following series of values :—

Table III.

| Station | No. Sets | $[v'v']$ |
|----------------------|----------|----------|
| Dehra Dún (Room) ... | 4 | 155 |
| „ (Tent) ... | 2 | 85 |
| Cuttack ... | 3 | 35 |
| Chatra ... | 3 | 165 |
| Kisnapur ... | 2 | 0 |
| Jalpaiguri ... | 3 | 163 |
| Kesarbari ... | (1) | ... |
| Ramchandpur ... | 3 | 817 |
| Siliguri ... | 4 | 262 |
| Darjeeling ... | 3 | 6 |
| Kurseong ... | 4 | 157 |
| Sandakphu ... | 3 | 5 |
| Dehra Dún (Room) ... | 3 | 45 |
| Dehra Dún (Tent) ... | 3 | 17 |
| Totals ... | 40 | 1912 |

The number of stations is 13.

Hence

$$\begin{aligned}\mu_0 &= 0.6745 \sqrt{\frac{1912}{40-13}} \\ &= \pm 5.7\end{aligned}$$

By method A we had

$$\rho_0 = \pm 3.1$$

As in the case of the observations ending in June 1904, we have μ_0 larger than ρ_0 .

The difference shows that the cause of a large proportion of the total error does not affect the differences between the individual pendulums and the mean pendulum in any set, but produces differences from set to set.

This cause is probably twofold, namely,

- (1) Differences between the temperatures of the pendulums and the temperatures recorded by the thermometers,
- (2) Variations of clock rate.

During the hours of observation when the temperature is being constantly watched and to some extent controlled, it is probable that the difference between the real temperature of each pendulum and that recorded by the thermometer is fairly constant, but the amount of this difference will depend on the conditions antecedent to the commencement of the observation, and these conditions will differ from day to day according to the state of the weather.

Also if the clock rate is constant during the hours of observation no discrepancy between the actual rate and the rate adopted for the period of 24 hours will affect the differences between the individual pendulums and the mean pendulum, but it might well occur, when the temperature is variable, that the mean of the actual rates during the night and day observations would differ to some extent from the 24-hourly rate, and so produce discrepancies from set to set. Besides this the observed daily rates are no doubt burdened with a certain amount of error.

Both cause (1) and cause (2) should have had less influence at stations where suitable observing rooms were available than at those where the conditions were less favourable. To examine this I have computed the probable errors by both methods for the following stations of the season 1904-05:—Dehra Dún (Room), Jalpaiguri, Darjeeling, Kurseong, Sandakphu and Dehra Dún (Room).

The results are:—

By method A $\rho = \pm 6.8$

Whence $\rho_0 = \pm 3.4$

By method B $\mu_0 = \pm 4.2$

The former results were respectively

$$\rho_0 = \pm 3.1 \text{ and } \mu_0 = \pm 5.7$$

There is therefore a considerable diminution of the discrepancy, though it is clear that even in the rooms the causes discussed had a considerable effect.

If we call the probable error due to these causes r

$$r = \sqrt{\mu_0^2 - \rho_0^2}$$

And we have

(1). For the observations of Chapter II ... $r = \pm 3.6$

(2). For the observations of Chapter III
 (a) when all the stations are included ... $r = \pm 4.8$
 (b) when only the stations with rooms
 are included $r = \pm 2.4$

The large values of v at Madras and at the Camel's Back station Mussooree are to be chiefly attributed to want of experience on the part of the observer and to unsteady temperature.

The large values of the same quantity at Ramchandpur, and at Dehra Dún in May 1905, and the very large value of $[v'v']$ at Ramchandpur, are worthy of attention.

With regard to Dehra Dún it is possible that these discordances were due to earth tremors caused by the after-shocks of the great Kangra Earthquake of April 4, 1905. Dehra Dún lies very near, in fact almost within the epifocal region* of that earthquake; its effects there were disastrous, and a great number of small after-shocks were no doubt taking place during the month of May. The absence of any notable irregularity during the observations in the tent (May 12th — 15th) does not prove that the discrepancies of 18th and 19th were not due to tremors, for there may accidentally have been a quiet period while the first series of observations was in progress.

At Ramchandpur the pendulums were swung in a hut built under a mango tree. This position was chosen for the sake of the protection from the sun that the tree afforded, but it has since occurred to me that the neighbourhood of a large tree is not a good place. If there is any wind the ground round the tree must be subject to many vibrations communicated by the branches, through the trunk, to the roots. I have unfortunately no note as to whether there was or was not much wind during my stay at Ramchandpur.

The Season 1905-06.

Using the values of v in Table III of Chapter IV we have after squaring and summing,

| | | | | |
|----------|------|------|------|-----|
| Pendulum | 137 | 138 | 139 | 140 |
| $[vv]$ | 1370 | 1005 | 1338 | 860 |

The total number of sets is 46.

$$\begin{aligned} \text{Hence} \quad \rho &= 0.6745 \sqrt{\frac{4573}{3 \times 45}} \\ &= \pm 3.9 \\ \text{and} \quad \rho_0 &= \pm 2.0 \end{aligned}$$

Now taking the differences between the station-means and the means of the single sets we have

Table IV.

| Station | No. of sets | $[v'v']$ |
|------------------------|-------------|----------|
| Dehra Dún | 3 | 114 |
| Simla | 3 | 218 |
| Kálka | (1) | ... |
| Ludhiána | 4 | 27 |
| Mián Mir | 3 | 17 |
| Ferozepore | 3 | 17 |
| Patháńkot | 3 | 145 |
| Montgomery | 3 | 32 |
| Dera Gházi Khan | 3 | 146 |
| Multán | 3 | 162 |
| Jacobabad | 3 | 3 |
| Sibi | 2 | 13 |
| Mach | 2 | 41 |
| Quetta | 3 | 26 |
| Dehra Dún | 4 | 27 |
| Totals | 42 | 988 |

* Vide Prof. Omori's map in the "Publications of the Earthquake Investigation Committee" No. 24, Tokyo, Japan, 1907.

The number of stations is 14.

$$\begin{aligned}\text{Hence } \mu_0 &= 0.6745 \sqrt{\frac{988}{42-14}} \\ &= \pm 4.0\end{aligned}$$

As in the previous series of observations, μ_0 is larger than ρ_0 .

In the present case the quantity which has been called r has the value

$$\pm 3.5$$

The Season 1906-07.

Proceeding as before, but omitting from consideration the observations made at the beginning of the season at Dehra Dún, on account of the change in Pendulum No. 137 that took place just after the observations there, we obtain for this season the following results:—

| | | | | |
|----------|-----|-----|-----|-----|
| Pendulum | 137 | 138 | 139 | 140 |
| [vv] | 783 | 342 | 438 | 604 |

The total number of sets is 33.

$$\text{Hence } \rho = 0.6745 \sqrt{\frac{2167}{96}}$$

$$= \pm 3.2$$

and

$$\rho_0 = \pm 1.6$$

Now using method B, we have

Table V.

| Station | No. of sets | [v' v'] |
|---------------|-------------|---------|
| Dehra Dún ... | 3 | 49 |
| Hardwár ... | 3 | 5 |
| Roorkee ... | 4 | 27 |
| Nojli ... | 3 | 49 |
| Kaliána ... | 4 | 23 |
| Meerut ... | 3 | 1 |
| Gesupur ... | 3 | 11 |
| Mohan ... | 2 | 8 |
| Asarori ... | 2 | 1 |
| Fatchpur ... | 2 | 18 |
| Kálsi ... | 2 | 18 |
| Rájpur ... | 2 | 1 |
| Dehra Dún ... | 3 | 9 |
| Totals ... | 36 | 220 |

The number of stations is 13.

$$\begin{aligned}\text{Hence } \mu_0 &= 0.6745 \sqrt{\frac{220}{36-13}} \\ &= \pm 2.1\end{aligned}$$

The good accordance between the two values ± 2.1 and ± 1.6 shows that during this season the cause of discrepancies between sets has been to a large extent overcome. This may be safely attributed to the introduction of the thermometer in the dummy pendulum for measuring the temperature of the pendulums. There was no change in the clock nor in the instruments used in the time observations, and the rooms occupied were not superior to those of the season 1905-06; we may conclude therefore that of the two possible causes mentioned on p. 177, the first was the more potent.

The quantity r for this season

$$\begin{aligned} &= \sqrt{2.1^2 - 1.6^2} \\ &= \pm 1.4 \end{aligned}$$

The investigation of the errors has so far taken into consideration only the discrepancies between the observed values of the time of vibration at the several stations. When we come to consider the differences between these times and those observed at the Base station, Dehra Dún, there are other sources of error to be taken into account, for there are several errors which are constant throughout the whole of the observations at a station, but which differ from station to station. I enumerate some of them here.

1. Errors in the flexure correction.
2. Errors in the corrections of the thermometers.
3. Errors in the corrections of the barometer and hygrometer.
4. Error in the constant of the temperature correction.
5. Error in the constant of the density correction.
6. Errors due to changes in the lengths of the pendulums.

I shall discuss them *seriatim*.

1. The flexure correction.

An examination of the observed values of the flexure correction will show that the p.e. of the adopted mean seldom exceeds ± 0.5 . I shall take its value to be ± 1.0 . There seems no reason to suppose that the error of the determination is greater when the flexure is large than when it is small, at least within the moderate variations actually encountered. At some few stations where the flexure was unsteady, owing to the cement in the pillar not having hardened when the observations began, there will no doubt have been a greater liability to error, but these cases were rare and need not be considered further.

2. The correction to the thermometer readings.

All the thermometers used for determining the temperatures of the pendulums have had their corrections determined on three separate occasions at the National Physical Laboratory at Kew. On the first two occasions the readings were made to 0.05 of a degree centigrade, and on the third occasion to 0.02. The determinations agree well with one another and I do not think that the difference of two corrected readings is likely to have a p.e. from this cause, of more than ± 0.02 . It is to be remarked that we are concerned with differences of temperature only, not with absolute temperatures.

If the p. e. of the difference of temperature be ± 0.02 , that of the difference of the times of vibration will be

$$\pm 0.02 \times 49 = \pm 1.0.$$

3. The corrections to the barometer and hygrometer.

These may be entirely neglected. An error of 1 millimetre in the height of the barometer has no effect on the correction to the time of vibration, and errors in the hygrometer are of still less importance.

4. The constant of the temperature correction.

The value of this constant was determined both at Potsdam and at Kew: the results are given on p. 5 of this paper. The value which has been used for all the reductions is 49, and from the figures on p. 5 we may estimate that the p.e. of this value is not greater than ± 0.2 . If C be the difference between the average temperature of the pendulums at any station and the mean of the temperatures at Dehra Dún during the opening and closing sets of observations, the p.e. of the difference between the reduced times of vibration will be

$$\pm 0.2 \times C.$$

The error will be different for each station; but it will be sufficient here to find its average value and its extreme value for each season.

In the season which ended in June 1904 the mean of the temperatures at Dehra Dún was $21^{\circ}0$, the average of the temperatures at the other stations $20^{\circ}8$, and the temperature which differed most from $21^{\circ}0$ was that at Mussooree (Camel's Back), where it was $14^{\circ}0$.

Thus the average p.e. was ± 0.04

And the greatest p.e. was ± 1.4 .

In the season 1904-05 the mean of the temperatures at Dehra Dún was $22^{\circ}7$, the average at the other stations $17^{\circ}6$, and the lowest $8^{\circ}3$ at Sandakphu.

Hence the average p.e. was ± 1.0

And the greatest p.e. was ± 2.9

For the season 1905-06 the figures were:—

| | | | |
|-------------------------------|-----|---------------|------------|
| At Dehra Dún ... | ... | $23^{\circ}5$ | |
| Average of field stations ... | ... | $16^{\circ}8$ | |
| Extreme ... | ... | $10^{\circ}8$ | (At Simla) |

Hence the average p.e. was ± 1.3

And the extreme p.e. was ± 2.5 .

For the season 1906-07 the temperatures were:—

| | | | |
|--------------------------------|-----|---------------|------------|
| At Dehra Dún ... | ... | $20^{\circ}8$ | |
| Average of fields stations ... | ... | $18^{\circ}4$ | |
| Extreme ... | ... | $15^{\circ}1$ | (At Nojli) |

Hence the average p.e. was ± 0.5

And the extreme p.e. was ± 1.1

For any ordinary station, then, a liberal estimate of the p.e. of the difference between the reduced times of vibration due to uncertainty in the temperature constant will be ± 1.0 .

5. The constant of the density correction.

The value of this constant also was determined both at Kew and at Potsdam. The means of the two sets of values (vide p. 4) differ by 1.7 per cent. The Potsdam values have been used throughout, and from the probable errors given that of the mean is ± 1.8 or 0.3 per cent.

A reasonable assumption will be that the p.e. does not exceed 1.0 per cent.

On this account, then, the p.e. of the difference between the times of vibration at Dehra and at any other station is $\pm 5.95 \times (\text{Density at Dehra} - \text{Density at Station})$.

The average density at Dehra is about 0.848, and at ordinary stations in the plains of India it is about 0.930. The p. e. corresponding to this difference is

$$\pm 0.5$$

The lowest density so far met with was that at Sandakphu, namely 0.626.

The maximum p. e. therefore was ± 1.3

I have adopted ± 0.8 as the normal value of this probable error.

6. Changes in the lengths of the pendulums.

Minute changes of an accidental character such as would be occasioned by slight movements of the agates in their bearings, or by particles of dust or moisture adhering to the surface of the pendulums have been instrumental in forming the discrepancies whence ρ_0 and μ_0 have been computed and need not be further considered. Systematic changes of individual pendulums with reference to the others have also had their effect on ρ_0 , and when considerable they have been allowed for, as in the case of Pendulum No. 140 during the season 1904-05, and of Pendulum No. 137 in November 1906, but such changes, as well as others affecting all the pendulums similarly, will produce an uncertainty as to the proper value of the time of vibration at the Base station with which comparison should be made. If, for instance a change of x in the time of vibration took place between the opening and the closing observations, the question is, "When did the change take place?" If it was a slow progressive change then the quantity x should be distributed evenly over the stations; but if the change took place suddenly, say after the first field station, then that station should receive no correction and all the others should receive a correction of x .

The time of vibration at Dehra Dún has been taken to be the mean of the observed times before and after the field season*, and the discrepancies between these times afford a means of estimating the uncertainty arising from changes in the pendulums.

The times in question were:—

| | | | Time of vibration | Diff. |
|---------------------------|-----|-----|----------------------|-------|
| January and February 1904 | ... | ... | 0.5072528 | |
| May and June 1904 | ... | ... | 2519 | - 9 |
| November 1904 (Room) | ... | ... | 2522 | |
| May 1905 „ | ... | ... | 2509 | -13 |
| November 1904 (Tent) | ... | ... | 2504 | |
| May 1905 „ | ... | ... | 2502 | - 2 |
| November 1905 | ... | ... | 2506 | |
| April 1906 | ... | ... | 2515 | + 9 |
| November 1906 | ... | ... | 2508 | |
| April 1907 | ... | ... | 2505 | - 3 |

These differences do not depend wholly on changes in the pendulums and it is only possible to form an idea of the uncertainty due to this cause. If we treat each pair of values as if it consisted of two observations of the same thing, the difference being an accidental error, the average p. e. of the mean of a pair is

$$\pm 2.8.$$

I shall adopt ± 3.0 as the value of the p. e. due to changes in the pendulums, *except in the season 1904-05 for which I shall assign ± 4.0 .*

* In two cases special corrections were first applied.

It has been pointed out that the error represented by r will be in part due to errors in the determination of the clock rate. The amount of this error must therefore be examined.

In the following tables I give an example of the time observations at a station :—

Station Gesupur.

Table VI.—Dislevelment of Transit Axis.

| Date | March 3rd | March 4th | March 5th | March 6th |
|---------------------|------------------|------------------|------------------|------------------|
| At Beginning | + 3 ⁷ | + 3 ³ | + 2 ⁵ | + 3 ⁴ |
| At End | + 4 ³ | + 4 ³ | + 5 ⁰ | + 4 ² |
| Mean | + 4 ⁰ | + 3 ⁸ | + 3 ⁸ | + 3 ⁸ |

Table VII.—Deviation in Azimuth.

| Star | March 3rd | March 4th | March 5th | March 6th |
|----------------------------------|----------------------|----------------------|----------------------|----------------------|
| ϵ Ursae Minoris (S. P.) | West 13 ² | West 13 ⁷ | West 16 ⁵ | West 18 ⁴ |
| δ Ursae Minoris (S. P.) | „ 14 ⁴ | „ 15 ⁶ | „ 17 ² | „ 19 ² |
| 51 (Hev.) Cephei ... | „ 15 ⁰ | „ 19 ¹ | „ 20 ³ | „ 22 ² |
| Mean | „ 14 ² | „ 16 ¹ | „ 18 ⁰ | „ 19 ⁹ |

Table VIII.—Abstract of Corrected Times of Transit and Deduced Clock Rates at Gesupur.

| Star | Zenith Distance | Aspect | Times of Transit | | | | Clock Rate | | |
|--|-----------------|--------|--------------------------------|----------------------|----------------------|----------------------|------------------------|------------------------|------------------------|
| | | | 1907 3rd March | Mar. 4th | Mar. 5th | Mar. 6th | 3rd—4th | 4th—5th | 5th—6th |
| ι Aurigae | 4 28 | N | ^{h m s} 4 52 11.95 | ^s 8.91 | ^s 5.87 | ^s 2.90 | ^s — 3.04 | ^s — 3.04 | ^s — 2.97 |
| 1572 | 4 24 | S | 5 3 42.48 | 39.37 | 36.32 | 33.43 | — 3.11 | — 3.05 | — 2.89 |
| μ Aurigae | 9 50 | N | 8 19.62 | 16.58 | 13.59 | 10.53 | — 3.04 | — 2.99 | — 3.06 |
| 1627 | 4 44 | N | 13 20.29 | 17.19 | 14.23 | 11.21 | — 3.10 | — 2.96 | — 3.02 |
| 1648 | 0 41 | S | 16 24.85 | 21.86 | 18.73 | 15.79 | — 2.99 | — 3.13 | — 2.94 |
| β Tauri | 0 1 | S | 21 40.73 | 37.59 | 34.55 | 31.61 | — 3.14 | — 3.04 | — 2.94 |
| 1709 | 0 34 | N | 25 2.08 | 58.88 | 55.87 | 52.97 | — 3.20 | — 3.01 | — 2.90 |
| 1723 | 3 35 | N | 27 56.39 | 53.25 | 50.25 | 47.30 | — 3.14 | — 3.00 | — 2.95 |
| ζ Tauri | 7 28 | S | 33 21.19 | 18.08 | 15.01 | 12.09 | — 3.11 | — 3.07 | — 2.92 |
| 1801 | 5 23 | S | 38 0.00 | 53.58 | 59.62 | 47.54 | ... | — 2.96 | — 3.08 |
| 1824 | 10 57 | N | 43 39.84 | 36.72 | 33.64 | 30.69 | — 3.12 | — 3.08 | — 2.95 |
| 1863 | 0 57 | S | 48 54.01 | 41.91 | 38.83 | 35.90 | — 3.10 | — 3.08 | — 2.93 |
| σ Aurigae | 8 39 | N | 54 38.92 | 35.72 | 32.58 | 29.63 | — 3.20 | — 3.14 | — 2.95 |
| η Geminorum | 6 1 | S | 6 10 32.00 | ... | 25.75 | 22.76 | ... | ... | — 2.99 |
| 2021 | 6 42 | N | 13 56.63 | 33.51 | 50.52 | 47.54 | — 3.12 | — 2.99 | — 2.98 |
| μ Geminorum | 5 59 | S | 18 36.17 | 33.11 | 30.08 | 27.08 | — 3.06 | — 3.03 | — 3.00 |
| 2084 | 8 0 | S | 23 41.08 | 37.91 | 34.83 | 31.95 | — 3.17 | — 3.08 | — 2.88 |
| 2130 | 2 58 | N | 30 0.00 | 13.94 | 10.95 | 8.01 | ... | — 2.99 | — 2.94 |
| 51 Aurigae | 10 55 | N | 33 29.17 | 26.06 | 22.99 | 20.15 | — 3.11 | — 3.07 | — 2.84 |
| ϵ Geminorum | 3 20 | S | 39 0.00 | 25.71 | 22.64 | 19.75 | ... | — 3.07 | — 2.89 |
| σ Geminorum | 5 31 | N | 47 55.77 | 52.67 | 49.62 | 46.67 | — 3.10 | — 3.05 | — 2.95 |
| 2254 | 3 3 | S | 50 51.83 | 48.67 | 45.60 | 42.74 | — 3.16 | — 3.07 | — 2.86 |
| Mean Rate | | | | | | | — 3.11 | — 3.04 | — 2.95 |
| Correction on account of Change in R. A. | | | | | | | + 0.02 | + 0.02 | + 0.02 |
| Final Mean Rate | | | | | | | — 3.09 | — 3.02 | — 2.93 |
| Probable Error of Mean Rate ... | | | | | | | ± 0.009 | ± 0.007 | ± 0.009 |

The number of stars observed may be thought unnecessarily large but when the plan is followed of observing the same stars each night, a few passing clouds might render the whole programme useless unless the observations extended over a considerable time.

The p. e. of the clock rate being about ± 0.01 , that of the reduced time of vibration will be

$$\pm 59 \times 10^{-7} \times 0.01 = \pm 0.06 \times 10^{-7}$$

This value should be slightly increased on account of the p. e. of the level correction, any uncertainty in which affects the time of transit of all the stars in the same way. No increase is necessary on account of uncertainty in the azimuthal deviation, for the programme is always divided equally between stars north and south of the zenith so that a cancelment of errors is brought about.

The value $\pm 0.8 \times 10^{-7}$ may be assigned to the total p. e. on account of errors in the determination of the clock rate. Thus in the season 1906-07 the quantity r is almost wholly accounted for.

The p. e. just found is not to be looked upon as a new source of uncertainty in the observed time of vibration, for it enters into μ_0 and has therefore been already taken into account.

Having now arrived at values for the various errors I shall build up the probable error of the difference between the times of vibration at the Base and at a field station. This total p. e. I shall call E , taking as my unit the seventh decimal place of a second.

The p. e. represented by μ_0 appertains to the time of vibration of the mean pendulum derived from one set of observations: if there were during any season on an average n sets at each station, then the quantity to be used for that season, which I shall call μ_s , is

$$\sqrt{\frac{\mu_0}{n}}$$

In the early part of 1904 there were as a rule 4 sets of observations at each station; the value of μ_0 was ± 4.7 .

Hence

$$\mu_s = \pm 2.4$$

The time of vibration at a field station is therefore burdened with the following errors:—

| | | | | |
|----|-----------------------------|-----|-----|-----------|
| 1. | μ_s | ... | ... | ± 2.4 |
| 2. | In the flexure correction | ... | ... | ± 1.0 |
| 3. | In the thermometer readings | ... | ... | ± 1.0 |
| 4. | In the temperature constant | ... | ... | ± 1.0 |
| 5. | In the density constant | ... | ... | ± 0.8 |

| | |
|----------------|-----------|
| Sum of squares | ± 9.4 |
| Total p. e. | ± 3.1 |

The time of vibration at Dehra Dún, with which comparison has to be made, is the mean of two separate series of observations and we have accordingly

| | | | | | |
|----|-------------------------|-----|-----|-----|-----------|
| 6. | μ_s | ... | ... | ... | ± 1.7 |
| 7. | Flexure | ... | ... | ... | ± 0.7 |
| 8. | Change in the pendulums | ... | ... | ... | ± 3.0 |

| | |
|----------------|-----------|
| Sum of squares | 12.4 |
| Total p. e. | ± 3.5 |

(Errors 3, 4 and 5 above are functions of the differences in temperature and density and have not to be applied a second time).

Hence

$$E = \sqrt{9.4 + 12.4} = \pm 4.7$$

For the other seasons the figures are the same with the exception of μ_s , which has the following values :—

$$\begin{array}{ll}
 \text{For 1904-05} & \mu_s = \pm \frac{5.7}{\sqrt{3}} = \pm 3.3 \text{ at a field station} \\
 & \mu_s = \pm 2.4 \text{ at Dehra Dún} \\
 \text{For 1905-06} & \mu_s = \pm \frac{4.0}{\sqrt{3}} = \pm 2.4 \text{ at a field station} \\
 & \mu_s = \pm 1.7 \text{ at Dehra Dún} \\
 \text{For 1906-07} & \mu_s = \pm \frac{2.1}{\sqrt{3}} = \pm 1.2 \text{ at a field station} \\
 & \mu_s = \pm 0.9 \text{ at Dehra Dún}
 \end{array}$$

$$\text{Hence for the season 1904-05} \quad E = \sqrt{14.5 + 22.3} = \pm 6.1$$

$$\text{For 1905-06} \quad E = \sqrt{9.4 + 12.4} = \pm 4.7$$

$$\text{For 1906-07} \quad E = \sqrt{5.1 + 10.3} = \pm 3.9$$

These values of E are given in terms of the seventh decimal place as unit.

Having now evaluated the average probable errors of the differences in the times of vibration at the Base and at a field station for each season, it remains to show the corresponding probable errors of the deduced values of g .

The equation whence g at a field station is deduced is

$$s^2 g = s_0^2 g_0 = k$$

whence

$$g = \frac{k}{s^2}$$

$$dg = -\frac{2k ds}{s^3}$$

For the evaluation of $\frac{2k}{s^3}$ we may put

$$s_0 = s = 0.507$$

and

$$g_0 = 979$$

Hence

$$\begin{aligned}
 \frac{2k}{s^3} &= \frac{2 \times 979}{0.507} \\
 &= 3862
 \end{aligned}$$

Hence

$$\text{if } ds = 1 \times 10^{-7}$$

$$dg = 0.000386$$

$$\text{For the season ending in June 1904,} \quad E = \pm 4.7 \times 10^{-7}$$

$$\text{Therefore} \quad \text{p. e. of } g = \pm 0.0018$$

$$\text{For the season 1904-05} \quad E = \pm 6.1 \times 10^{-7}$$

$$\text{Hence} \quad \text{p. e. of } g = \pm 0.0024$$

$$\text{For the season 1905-06} \quad E = \pm 4.7 \times 10^{-7}$$

$$\text{Hence} \quad \text{p. e. of } g = \pm 0.0018$$

$$\text{For the season 1906-07} \quad E = \pm 3.9 \times 10^{-7}$$

$$\text{Hence} \quad \text{p. e. of } g = \pm 0.0015$$

These are the probable errors based on the observed value of g at Dehra Dún, viz., 979.063; they do not include the error with which that value may be burdened.

CHAPTER VII.

In the tables in which the results of each season's work are summarised the last column contains the value of the quantity $(g_o'' - \gamma_o)$

This quantity is the difference between the observed value of the force of gravity and that which theory would lead us to expect. In computing the corrections required for the reduction to sea level the density of the earth's crust, including all rock above sea level, has been assumed to be 2.8 and the mean density of the earth to be 5.6. If at any station $(g_o'' - \gamma_o)$ is a positive quantity it shows that the density of the strata underlying that station is greater than 2.8, and if it is negative that the density is less.

What the actual densities are we cannot say unless we know the depths to which the excesses or defects extend but we can indicate the total amount of matter of density 2.8 which must be added to, or subtracted from, that which is visible in order to produce the observed deviation from the normal.

The attraction of a circular disc on a point in its axis, situated at a height c above its upper surface, the radius of the disc being r , and its thickness h is

$$K \left\{ h + \sqrt{r^2 + c^2} - \sqrt{r^2 + (c + h)^2} \right\}$$

If r be very large compared with c and h this becomes Kh , that is to say the attraction depends on the thickness of the disc only, and is independent of the height of the station above it.

The value of K , when h is expressed in feet and the attraction in centimetres per second, and the density of the disc is taken to be half the mean density of the earth, is 0.000035.

Thus if we have to account for a deficiency in gravity of 0.001 c.m. we may say that there is a deficiency in the matter underlying the station equivalent to a disc of indefinitely great radius the thickness of which is

$$0.001 \div 0.000035 \quad \text{or} \quad 28.6 \text{ feet.}$$

In this way we can compute the amount of the excess or defect of matter underlying each station, obtaining the thickness of what has been called by Professor Helmert "Die Ideelle Störende Schicht". Adding or subtracting this thickness to or from the known height of the station we obtain an ideal height which would be that of the station if the strata underlying it were expanded or compressed, as the case may be, until they attained a density of 2.8.

This is only approximately true for the corrections to the observed g on account of the masses between the station and sea level, $\left(g \frac{3}{4} \frac{h}{R}\right)$ and O have been computed on the assumption of a density of 2.8, whereas the very facts that we are dealing with show that this was not the actual density. Furthermore, when we have several stations in a small area and we find that the deficiencies to be accounted for differ by considerable amounts, the method of explaining the deficiencies by

imagining each station to have under it a disc of indefinite extension and of a thickness proportional to the value of $(g_0'' - \gamma_0)$, breaks down, for we should have parts of two or more discs of different thicknesses under each station.

Nevertheless, since the central portion of the underlying disc is of much greater importance than the outer parts, the ideal heights give some idea of what would be the state of things if the crust were homogeneous and I have therefore drawn up a table to exhibit the actual heights, the thickness of the disturbing discs, and the ideal heights. In this table the stations have been grouped in regions.

Actual and Ideal Heights of Stations.

| Station | Actual Height feet | $g_0'' - \gamma_0$ c.m. | Thickness of disturbing disc feet | Ideal Height feet |
|-----------------------------|-----------------------|----------------------------|---|----------------------|
| Dehra Dun and Great Arc. | | | | |
| Mussooree (Dunseverick) ... | 7129 | - 0'115 | - 3289 | + 3840 |
| " (Camel's Back) ... | 6924 | - 0'110 | - 3143 | + 3781 |
| Rájpur ... | 3321 | - 0'124 | - 3546 | - 225 |
| Kálsi ... | 1684 | - 0'098 | - 2800 | - 1116 |
| Dehra Dún ... | 2239 | - 0'126 | - 3600 | - 1361 |
| Fatehpur ... | 1434 | - 0'100 | - 2857 | - 1423 |
| Asarori ... | 2467 | - 0'112 | - 3203 | - 736 |
| Hardwár ... | 949 | - 0'114 | - 3260 | - 2311 |
| Mohan ... | 1660 | - 0'104 | - 2974 | - 1314 |
| Roorkee ... | 867 | - 0'107 | - 3060 | - 2193 |
| Nojli ... | 879 | - 0'095 | - 2717 | - 1838 |
| Kaliána ... | 810 | - 0'058 | - 1659 | - 849 |
| Meerut ... | 734 | - 0'027 | - 772 | - 38 |
| Gesupur ... | 691 | - 0'020 | - 572 | + 119 |
| N. E. Longitudinal Series. | | | | |
| Sandakphu ... | 11766 | - 0'150 | - 4286 | + 7480 |
| Darjeeling ... | 6966 | - 0'143 | - 4090 | + 2876 |
| Kurseong ... | 4913 | - 0'130 | - 3718 | + 1195 |
| Siliguri ... | 387 | - 0'137 | - 3914 | - 3527 |
| Jalpaiguri ... | 268 | - 0'096 | - 2746 | - 2478 |
| Calcutta Meridional Series. | | | | |
| Kesarbari ... | 204 | - 0'043 | - 1230 | - 1026 |
| Ramchandpur ... | 132 | + 0'001 | + 29 | + 161 |
| Kisimpur ... | 113 | + 0'033 | + 944 | + 1057 |
| Chatra ... | 64 | + 0'009 | + 257 | + 321 |

Actual and Ideal Heights of Stations—(Continued).

| Station | Actual Height feet | 90"—70 c.m. | Thickness of disturbing disc feet | Ideal Height feet |
|---|-----------------------|----------------|---|----------------------|
| Other Himalayan and Sub-Himalayan Stations. | | | | |
| Simla ... | 7043 | - 0'119 | - 3403 | + 3640 |
| Kálka ... | 2202 | - 0'085 | - 2431 | - 229 |
| Patháńkót ... | 1088 | - 0'179 | - 5114 | - 4026 |
| Plains of the Punjab. | | | | |
| Ludhiána ... | 835 | - 0'048 | - 1373 | - 538 |
| Mián Mir ... | 708 | + 0'004 | + 114 | + 822 |
| Ferozepore ... | 647 | + 0'006 | + 172 | + 819 |
| Montgomery ... | 557 | + 0'003 | + 86 | + 643 |
| Multán ... | 404 | - 0'045 | - 1287 | - 883 |
| Dera Gházi Khan ... | 397 | - 0'088 | - 2517 | - 2120 |
| Baluchistan and Sind. | | | | |
| Quetta ... | 5520 | - 0'139 | - 3971 | + 1549 |
| Mach ... | 3522 | - 0'117 | - 3346 | + 176 |
| Sibi ... | 434 | - 0'116 | - 3318 | - 2884 |
| Jacobabad ... | 183 | + 0'031 | + 887 | + 1070 |
| Coast Stations. | | | | |
| Madras ... | 20 | + 0'014 | + 400 | + 420 |
| Colaba ... | 34 | + 0'088 | + 2514 | + 2548 |
| Cuttack ... | 92 | + 0'029 | + 829 | + 921 |

Plates IV, V, VI and VII have been drawn to show graphically the difference between the visible section of the earth's surface and the ideal section.

The upper diagram in each plate shows the actual or visible section, that is to say the ordinates represent the actual heights of the stations above sea level. The middle diagram shows the thickness of the disturbing disc, and the third shows the ideal section, that is to say, the ordinates in it are the sums of the corresponding ordinates of the other two.

Owing to the lengths of the sections represented being widely different, it has not been possible to draw them all on the same scale, but the proportion between the horizontal and vertical scales in Plates IV, V and VI is the same, the vertical scale being about 40 times as large as the horizontal*. Plate VII covers a much less horizontal distance and in it the exaggeration of the vertical is not so great, being only about 10 to 1.

* These diagrams were originally drawn on the scale 30 miles to 1 inch horizontal and 4000 feet to 1 inch vertical, and they were afterwards reduced by photography to fit the page.

In these diagrams the first point to be noticed is that in and near the foot-hills there is always a great deficiency in the force of gravity, the disturbing disc is always thick; but it is also to be remarked that under hills its thickness in no case equals the height of the hill and it does not increase with the height of the hill. Thus in Plate IV the defect is almost constant from Siliguri to Sandakphu, in Plate VI from Sibi to Quetta and in Plate VII from Asarori to Mussooree.

This constancy in the defect leads to the result that in the ideal section there is a deep dip at the foot of hills and this dip has an important bearing on the deflections of the plumb-line.

In Plate IV a dotted line has been drawn on the diagram of the ideal section to show the way in which the deflection of the plumb-line in the meridian varies.

Judging by the visible section it seems impossible to believe that at Ramchandpur and Kesarbari the plumb-line is deflected to the south; but if to account for this observed fact we assume that the visible mass of the Himalayas is wholly compensated by deficiencies of density, we are equally at a loss to account for the appearance of a northerly deflection at Jalpaiguri which rises with great rapidity to a maximum at Kurseong.

The great dip between Kesarbari and Kurseong explains the observed effects quite satisfactorily. At Kesarbari there is nearly a balance between the attraction of the mass to the south aided by the dip to the north, and that of the far greater, but more distant Himalayas to the north. At Jalpaiguri part of the dip is already to the south tending to counteract the effect of the remainder that still lies to the north, the Himalayas are more powerful than the mass to the south and the plumb-line is therefore deflected in their direction.

At Kurseong the dip and the Himalayas acting in harmony produce the largest deflection that has yet been observed in India.

On receding from the hills in a direction more or less at right angles to them the force of gravity approaches the normal value and finally exceeds it, as at Kisanpur in Plate IV, Mián Mir and Montgomery in Plate V and Jacobabad in Plate VI.

The observations detailed in Chapter V were not carried sufficiently far south to ascertain whether this rule holds good in that region also, but it is probable that it does, for, as the first part of the table shows, the deficiency in g_0'' was growing steadily less, and at Gesupur was only about a fifth part of what it was at Nojli.

The investigation of the position of the locus of maximum values of $(g_0'' - \gamma_0)$ is an important part of future pendulum operations.

Plate VIII shows the position of the stations near the Siwálíks and Himalayas the observations at which were given in Chapter V. The results are shewn in the first part of the table and in Plate VII. The noteworthy point is here the fact that the defects do not seem to be affected by the presence of the Siwálík range. There is for instance, no additional defect at Mohan or Hardwár. The difference from the normal seems to diminish with perfect regularity from Dehra Dún to Gesupur.

Throughout this area similarly placed stations have similar defects, though at western stations they are generally greater than at eastern ones.

| | | |
|------|------------------------------|--------------------|
| Thus | at Kálsi the defect is 0.098 | at Rájpur 0.124 |
| | at Fatehpur 0.100 | at Dehra Dún 0.126 |
| | at Mohan 0.104 | at Hardwár 0.114 |
| | at Nojli 0.095 | at Roorkee 0.107 |

These variations are however probably local.

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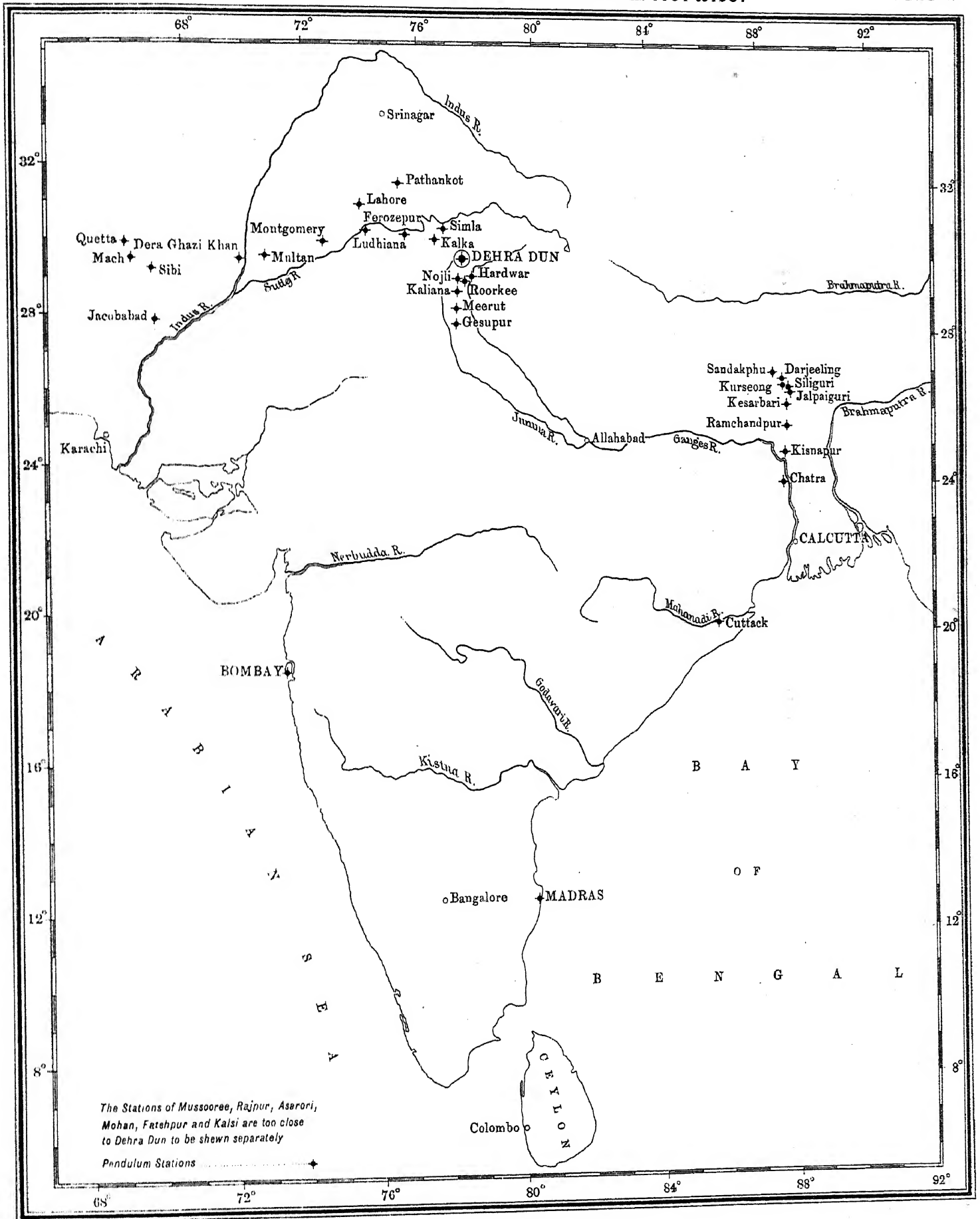
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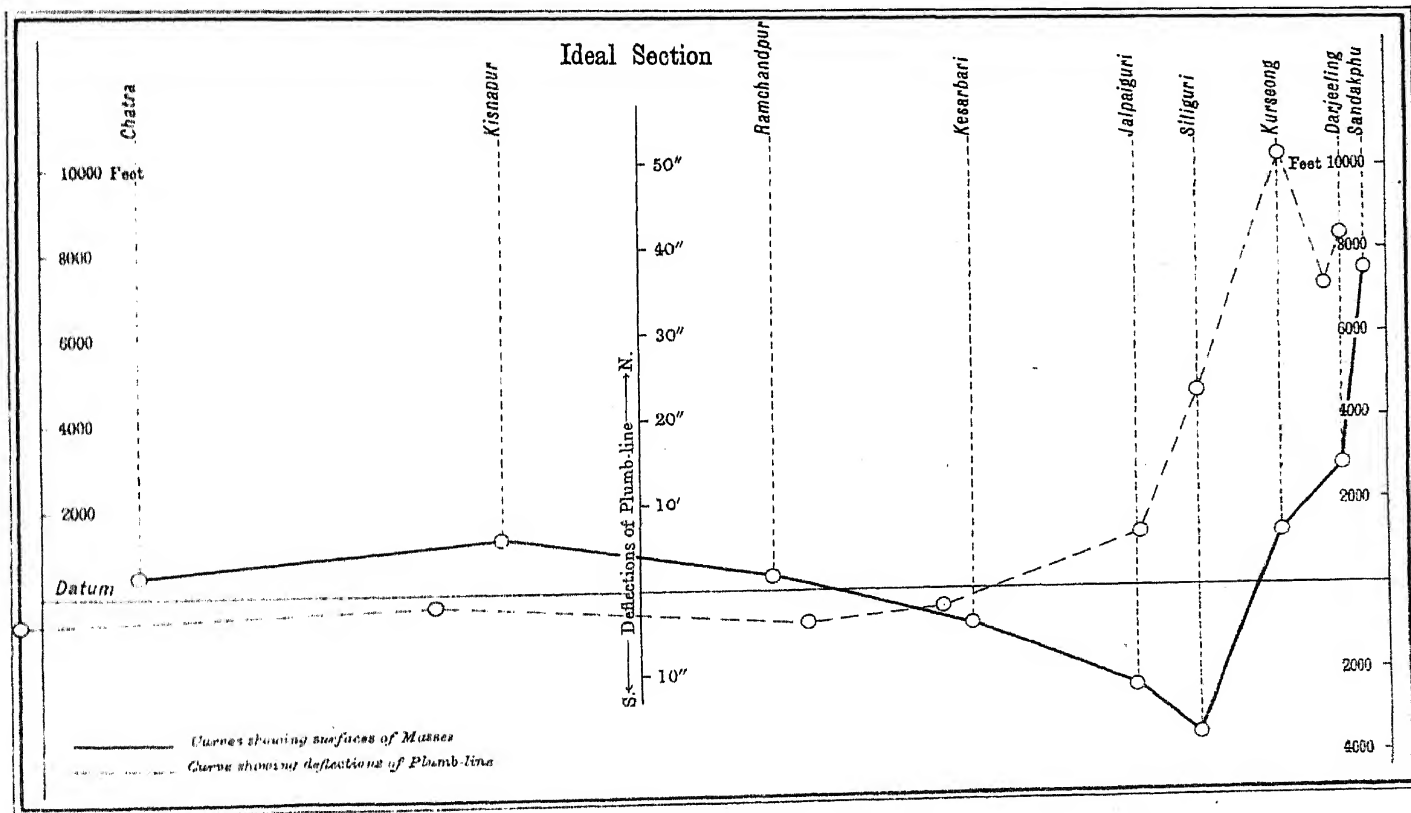
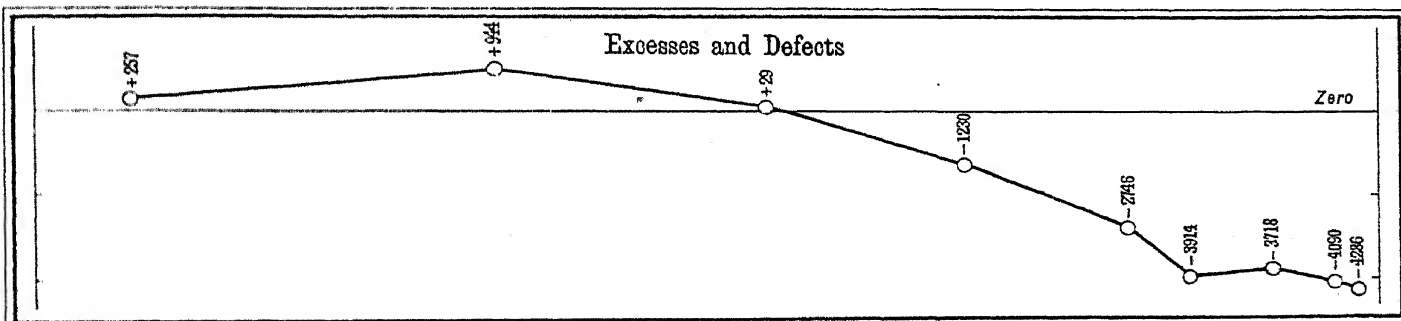
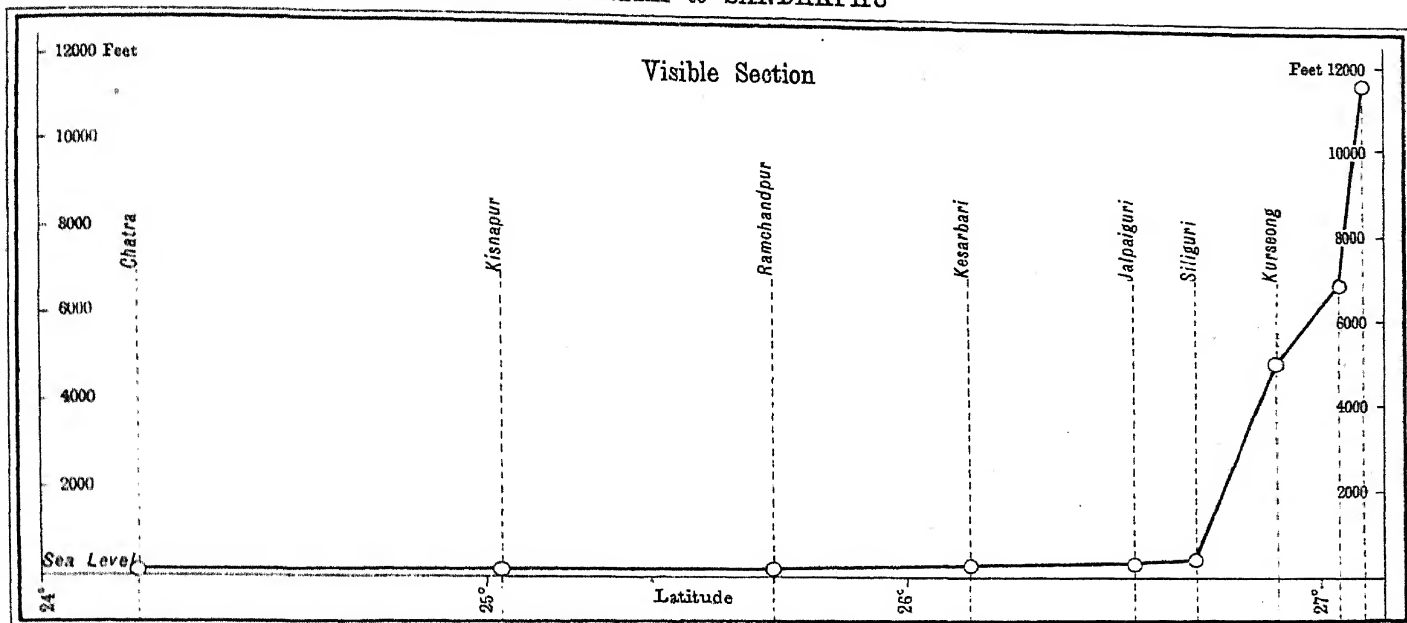
The table showing the real and ideal heights of all the stations is to be found on pp. 188, 189.

MAP Showing the PENDULUM STATIONS Seasons 1904 to 1907

PLATE III



SECTION from CHATRA to SANDAKPHU

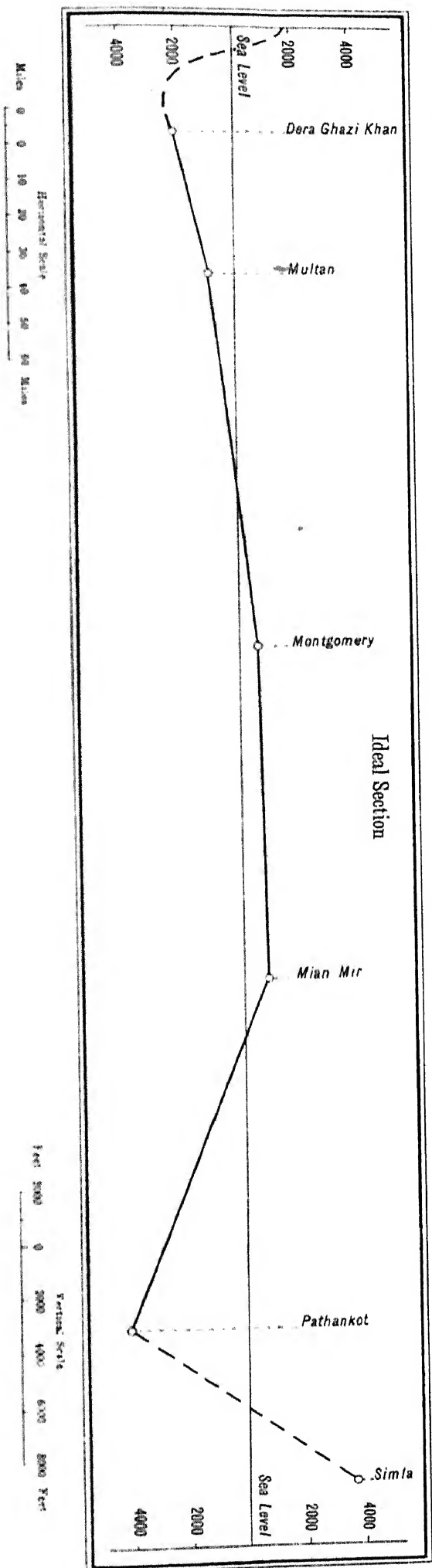
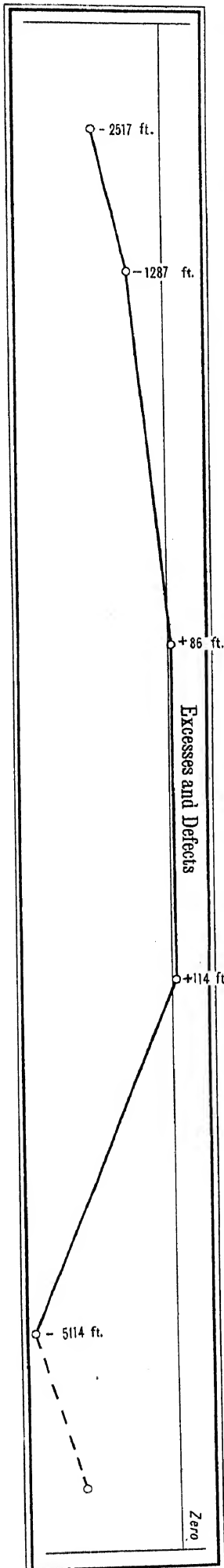
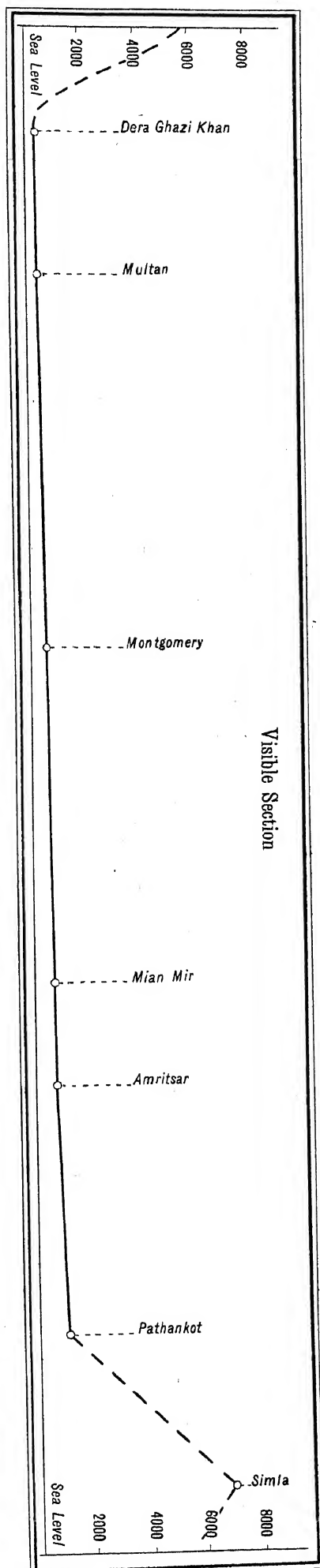


Horizontal Scale
Miles 0 10 20 30 40 50 60 Miles

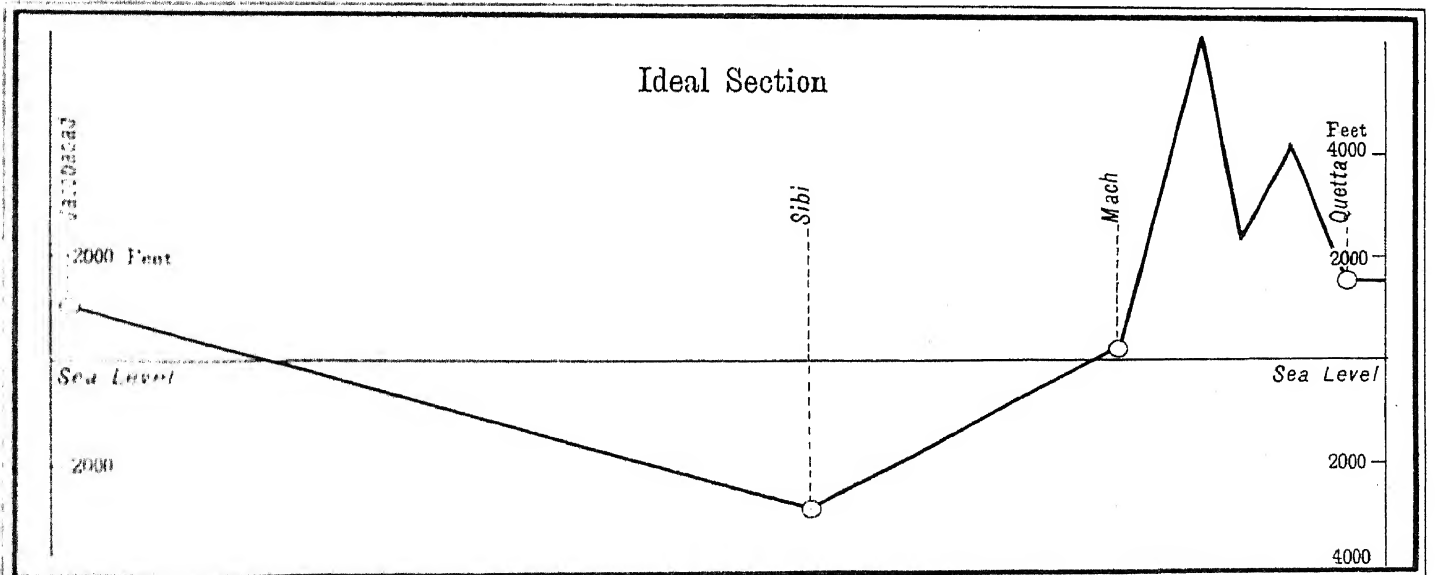
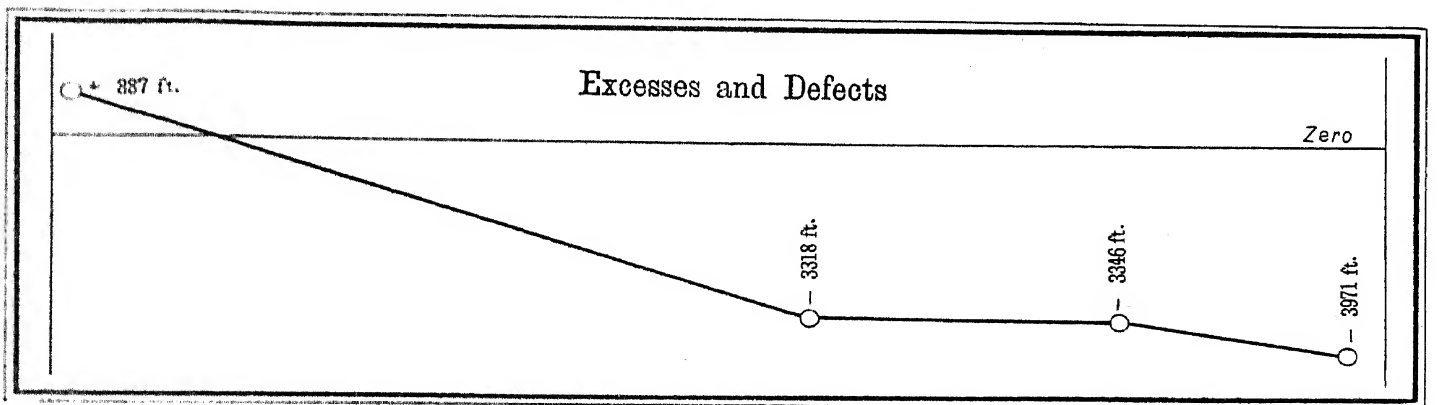
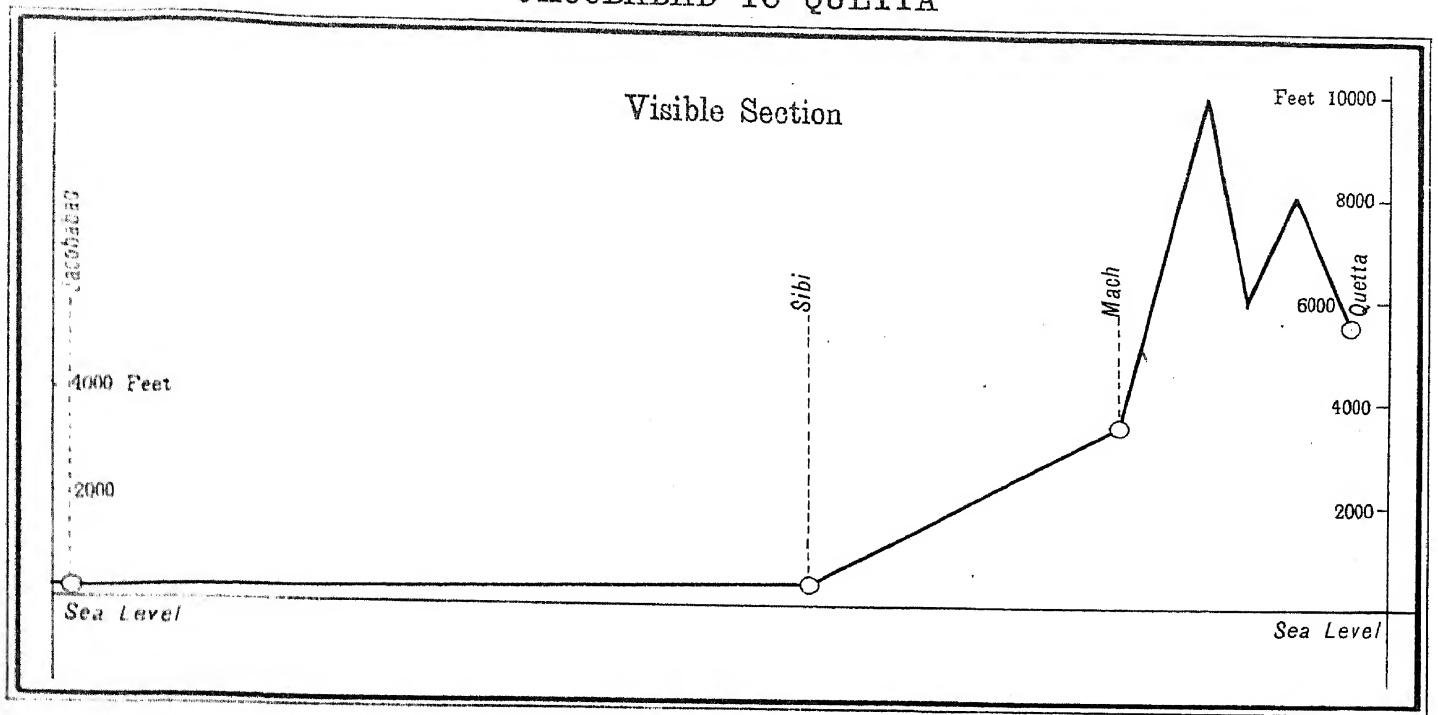
Vertical Scale
Feet 0 2000 4000 6000 8000 Feet

SECTION
from
THE SULEMAN MOUNTAINS
to
THE HIMALAYA

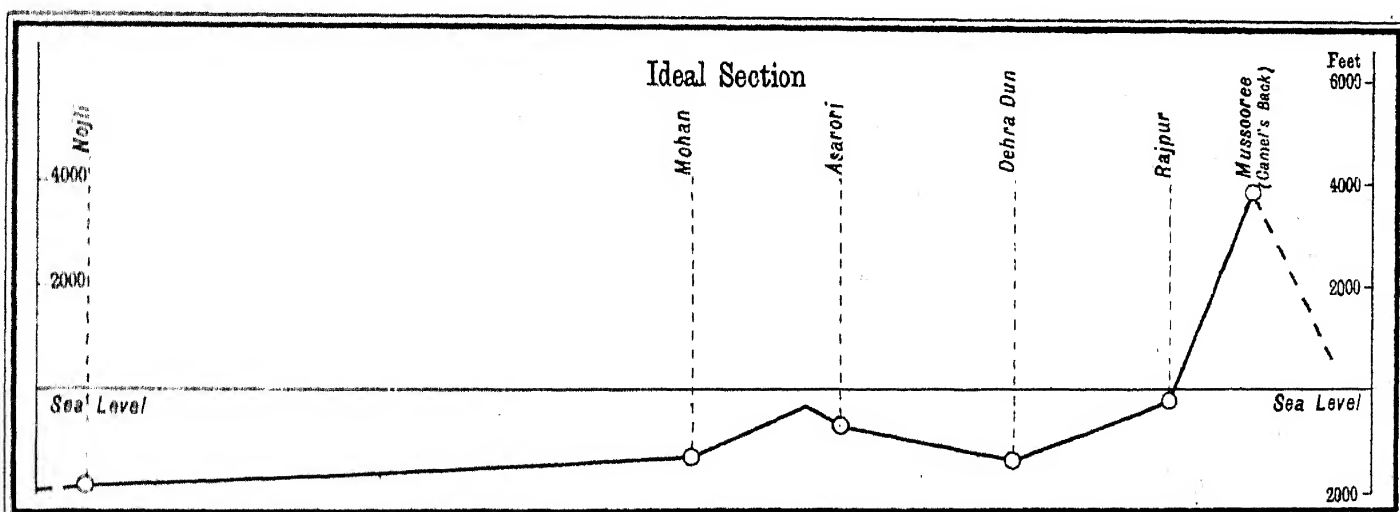
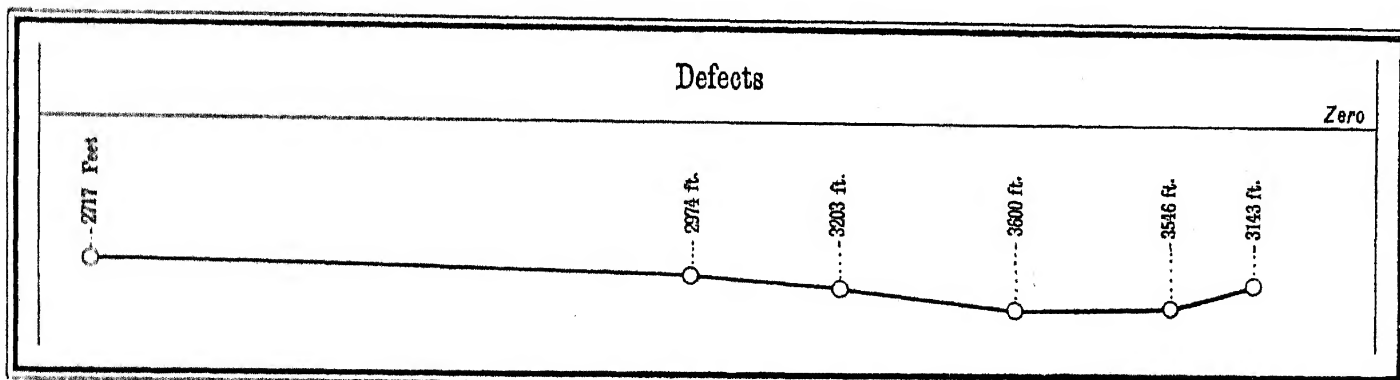
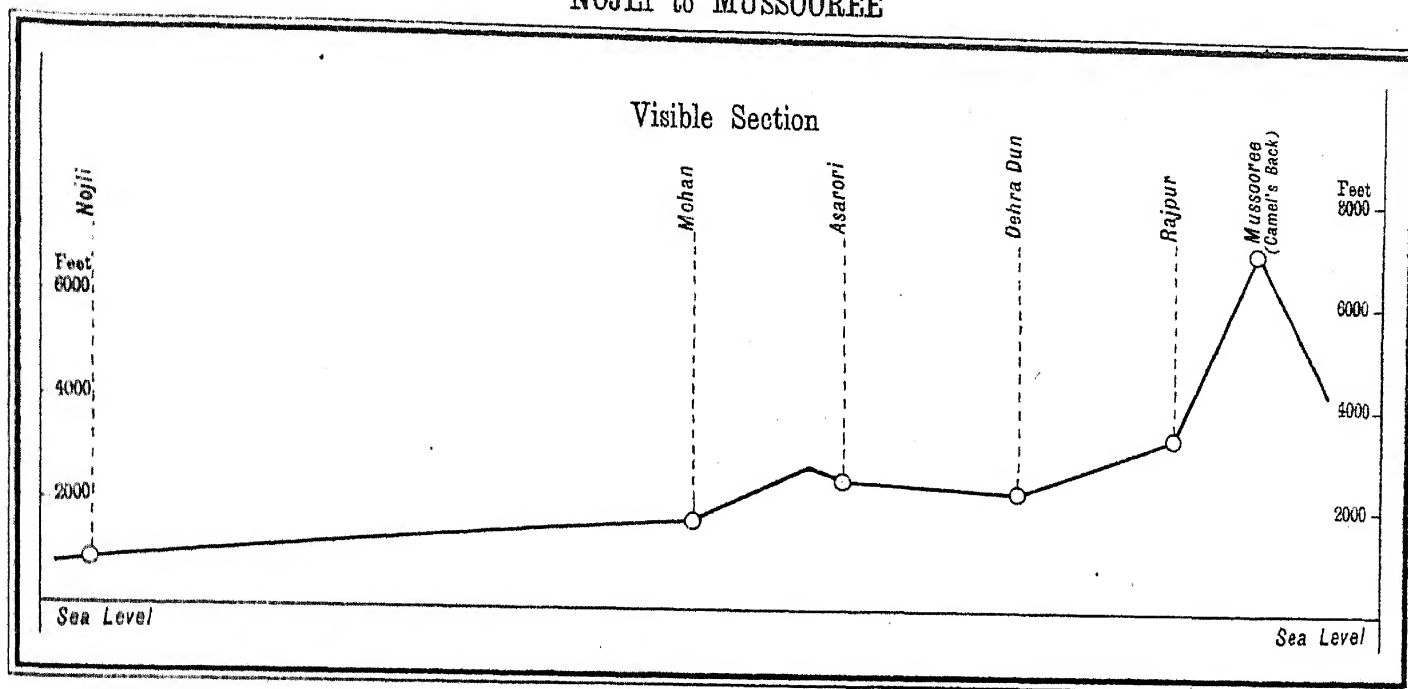
PLATE V.



SECTION from JACOBABAD TO QUETTA



LARGE SCALE SECTION from NOJLI to MUSSOOREE



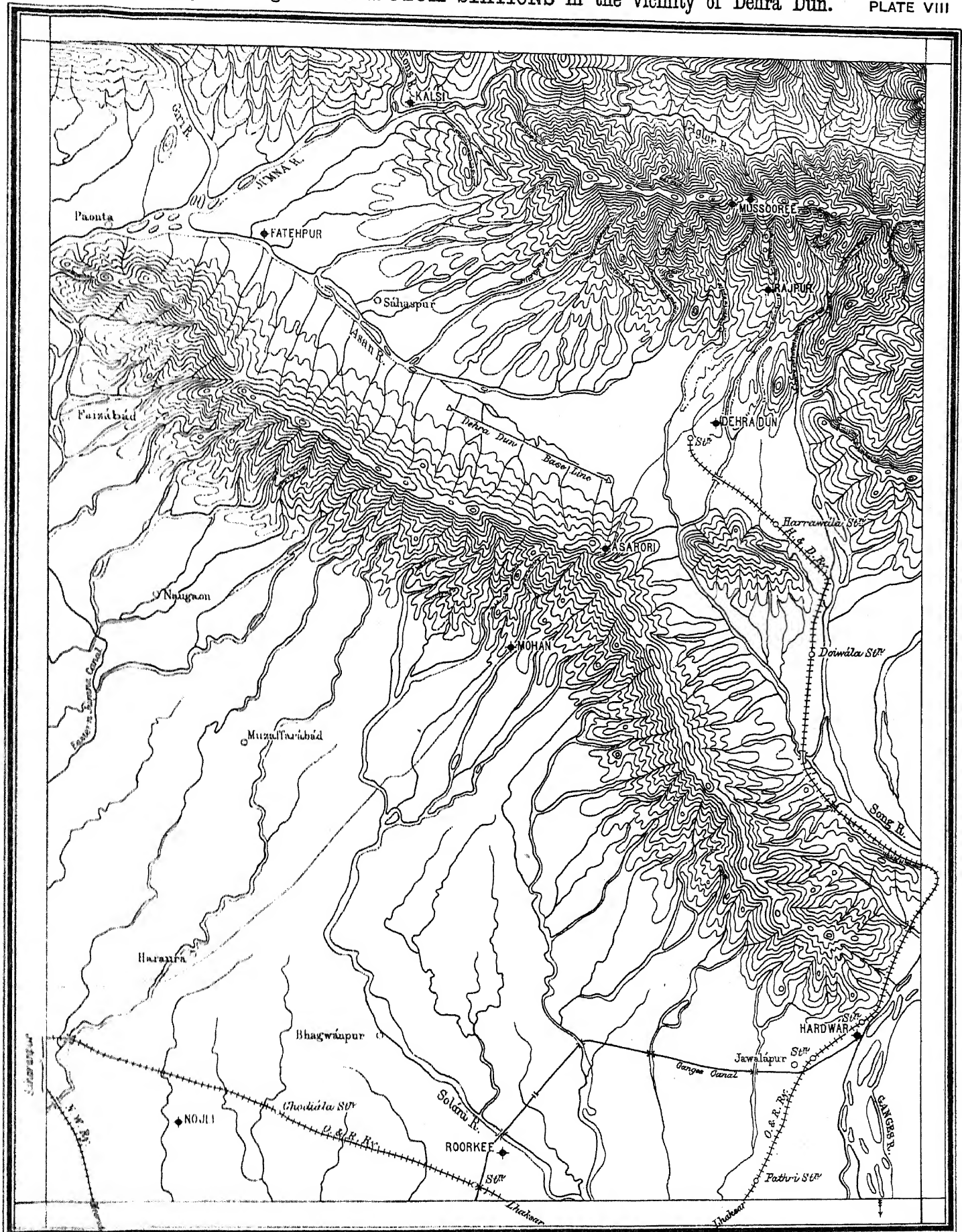
Horizontal Scale
0 2 4 6 8 10 12 14 16 Miles

Horizontal Scale 1 Inch = 8 Miles
Vertical Scale 1 Inch = 4000 Feet.

Vertical Scale
0 2000 4000 6000 8000 Feet

Map showing the PENDULUM STATIONS in the vicinity of Dehra Dun.

PLATE VIII



Pendulum Station ♦

